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FISKERIDIREKTORATETS SKRIFTER
Serie Havundersøkelser
(Report on Norwegian Fishery and Marine Investigations Vol. IV, No. 1)

Published by the Director of Fisheries

On the Age and Growth of the Cod *(Gadus callarias* L.) from the Norwegian Skagerrack Coast

By

ALF DANNEVIG

Investigations carried out at the Flødevig Sea-Fish Hatchery
with Financial Assistance from
A/S Norsk Varekrigsforsikrings Fond

1 9 3 3

A.s John Griegs Boktrykkeri, Bergen

NOTICE.

From economic and practical considerations it has been found necessary to change the size and typographical form of the series of memoirs published by the Norwegian Director of Fisheries under the title "Report on Norwegian Fishery and Marine Investigations". This change has been used as an opportunity of standardising the different publications of the Directorate which will, accordingly, henceforth appear under the common title of *"Fiskeridirektoratets Skrifter"*.

The serie: *Havundersøkelser* will, in the main, correspond to the earlier „Report" and the title "Report on Fishery and Marine Investigations" will therefore continue on the title page, henceforth as sub-title, and to meet library requirements the volumes of the marine investigations serie will be numbered in continuation of of the "Report", the present paper thus appearing as vol. IV, nr. 1.

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Manuscript finished August 1931.

Preface.

In a paper "On the Growth of the Cod and the Formation of annual Zones in the Scales. Experiments at the Flødevig Sea-fish Hatchery 1925" I drew attention to the difficulties met with in the study of scales of the cod from the Norwegian Skagerrack coast. Scales of cod captured in October often showed "winter zones" at the margin and "summer growth" appeared some months later in the middle of winter, in direct contrast with the ordinary scale theory.

The problem was studied by keeping cod in captivity at the Flødevig Sea-fish Hatchery, and the results of the experiments were summed up in the following way: (l. c., p. 21)

"On the basis of the facts mentioned, we may get the impression that the formation of small sclerites normally takes place in the autumn or late in the summer. For the individuals with slow growth the formation of small sclerites may be prolonged during the winter — slow growth gives small sclerites.

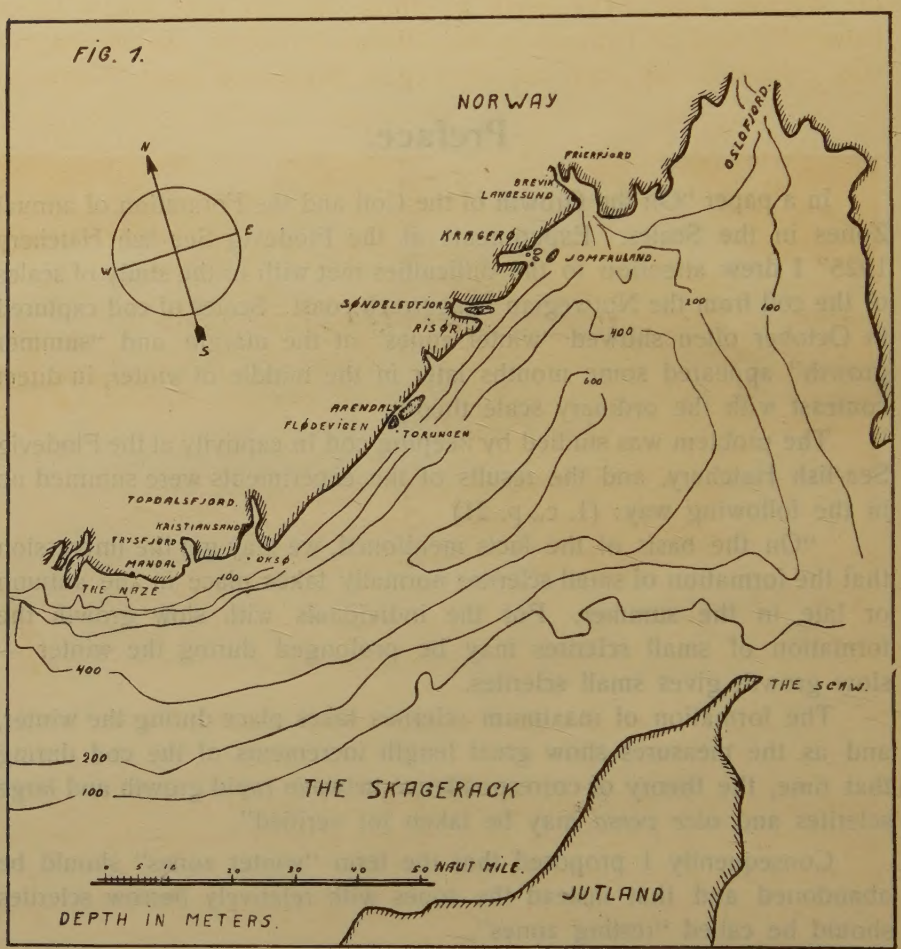
The formation of maximum sclerites takes place during the winter, and as the measures show great length increments of the cod during that time, the theory of correspondence between rapid growth and large sclerites and *vice versa* may be taken for verified".

Consequently I proposed that the term "winter zones" should be abandoned and that instead the zones with relatively narrow sclerites should be called "resting zones".

The results achieved could not, however, be applied to the cod in the sea without further investigations. Scales from free-living cod had to be studied in order to confirm or reject the conclusions reached from the rearing experiments and the preliminary inspection of scales from cod living under natural conditions.

When turning to such material from free-living cod it was first necessary to find out the season in which the zones were formed. This problem was approached in two ways: subjectively, by examining the margin of the scales of fish caught each month of the year, and, more

objectively, by measuring the sclerites near the margin. In addition the zones of the otoliths were also studied. The otoliths, however, could not yield precise measurements, as the zones were not sharply defined, and we had to depend on personal judgement only. During



the examination it became apparent that the otoliths were nevertheless greatly to be preferred to the scales for age determination.

As I became convinced that it was necessary to study the problem of age-determination with regard to the cod from different parts of the Norwegian Skagerrack coast, I began to collect material bearing on this problem.

Two fjords were chosen for this study, the Søndeledfjord and the Topdalsfjord, with the skjærgård near Flødevigen in addition. From

these three regions material was collected throughout the year. The fishing gear used was traps of galvanized iron netting covered with spruce twigs. One or two fishermen in each fjord were given traps, and were instructed to measure[1]) every fish caught, and to take samples of scales and otoliths. The material from Flødevigen was collected by the hatchery staff. The depth in which the cod were caught varied between 3 and 22 fathoms in the different localities. As the material was collected only from the Norwegian Skagerrack coast, it must be

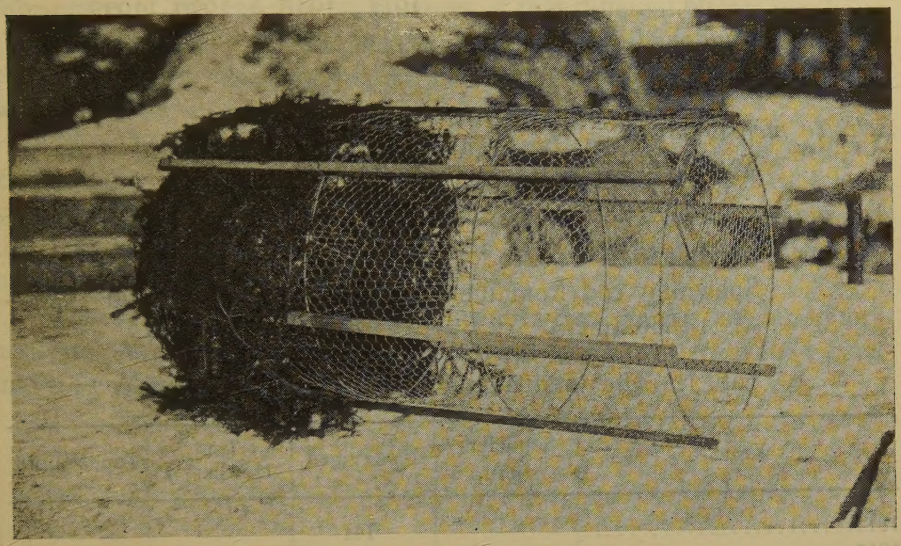


Fig. 2. Fish trap of galvanized iron netting. Length 1.5 metre.

emphasized that the methods adopted and results arrived at are not applicable to material from other waters without testing the methods on the material in question.

The collection of the material and the preliminary examination were made possible by yearly grants on the Budget of Fisheries. In order to have assistance in examining the material collected, I applied to A/S Norsk Varekrigsforsikrings Fond which generously voted 3000 kr. in both 1927 and 1928 for these investigations, and I was thus able to secure the assistance of two young zoologists from Oslo University, cand. real. Adolf Sørensen and stud. mag. Olaug Mathisen.

[1]) From the tables it may be seen that the fish have a tendency to accumulate at figures ending with 0 or 5, indicating that the measurements ought to have been more accurately made in some cases.

Mr. Sørensen examined the following materials:

Sclerite measurements:

Topdalsfjord ..... Oct. 1926—Dec. 1927.
Flødevigen ..... 1926 & 1927.
Søndeledfjord ..... 1927.

Age determination:

Topdalsfjord ..... 1924—1929 (incl.).
Flødevigen ..... 1923—1929 (incl.)
do. ..... 1914—1916 & 1920—1922.
Søndeledfjord ..... 1922.

And Miss Mathisen:

Sclerite measurements:

Søndeledfjord ..... 1928.

Age determination:

Søndeledfjord ..... 1923—1929 (incl.).
Spawning cod from the hatchery 1920 & 1921 and 1925—1930 (incl.).

Tab. 1. The total number of cod-fish examined.

Year	Søndeled-fjord	Flødevigen	The Hatchery[1])	Topdalsfjord
1914	—	141	—	—
1915	—	556	—	—
1916	—	72	—	—
1920	—	259	230	—
1921	—	244	225	—
1922	159	163	—	—
1923	87	120	—	—
1924	188	114	—	50
1925	355	190	191	491
1926	807	82	53	645
1927	453	198	111	258
1928	524	126	291	166
1929	567	66	151	126
1930	—	—	384	—
Total	3140	2331	1636	1736 = 8849

Simultaneously with the examination of the material from nature, further experiments were carried out at Flødevigen. Some larvae were

[1]) Cod spawning and spawned during spring.

reared in the pond, and some specimens from the sea were kept in captivity in an aquarium, or in confinement in the sea. Although the experiments are to be continued, some of the results obtained will be referred to here. The larvae reared furnish the material for the study of the scales in the early months of the cod's life, the other experiments providing the material for studying the growth of the cod from month to month as well as of the scales.

The results achieved with fish kept in captivity cannot of course be applied to free-living fish without further investigations. The great advantage of the experiment, however, is that different factors involving the well-being of the fish can be kept under control. For this purpose we made observations on the temperature and salinity of the water, and the quantity of food consumed.

As will be seen, these experiments tend to show that the ordinary explanation given for the occurrence of winter zones will not hold good for the cod. It is difficult to find any simple correlation between the length increment of the fish and the size of the sclerites, nor between the growth and the temperature.

The rearing experiments have been carried out by my laboratory assistant, Mr. R. Løversen. The measurements of the sclerites have been made by Mr. Sørensen.

II. The hydrography of the waters concerned, with special reference to temperature.

Before dealing with the cod material it may be worth while briefly to remark on the hydrography, especially the temperature of the waters in which the fish lived. This is, however, a rather difficult problem since in these waters the temperature generally varies greatly according to depth and, in the surface layers, from day to day. Moreover, as a rule we only know the approximate depth at which the fish is caught — not the depth at which it has lived.

On this part of the coast the great depths of the Skagarrack lie near to land; the banks are very narrow, and extend only a few miles from the coast. In some cases relatively great depths may be found in the skjærgaard and fjords as submarine basins. These basins may be so deep in relation to the threshold outside that the water will be more or less stagnant.

The surface water along the Norwegian Skagarrack coast, the Baltic current, is formed from the mixing of the waters of the brackish current coming from the Baltic, the Jutland current coming up on the west side of Jutland, the surface waters of the fjords and the typical Skagerrack-water. The salinity of this mixed water varies according to the season; in spring it is lowered by the melting of the snow, while in winter the salinity will increase on account of the fresh water being kept ashore as snow. The limit between the Baltic current and the Skagerrack water as far as salinity is concerned, may be set at 32 ‰. The temperature varies from zero (or even lower) to nearly 20 °C. In summer the current spreads out over the Skagerrack on account of the low specific gravity due to the low salinity and high temperature. In winter this water generally keeps close to land and extends deeper down. When strong, off-shore winds prevail, the current may be forced seaward, so that the underlying, relatively salt Skagerrack water may reach the surface in the skjærgaard. This also happens when the large waves in the intermediate layers approach the coast (Pettersson 1922). In winter these deeper layers are relatively warm, in summer relatively cold.

Fig. 3 illustrates the considerable variations which the temperature and salinity may undergo in this way from day to day at a fixed depth at Flødevigen. As it is probable that the cod emigrate when the temperature becomes very low or very high, it will be evident that the problem of studying the effect of temperature on the growth of

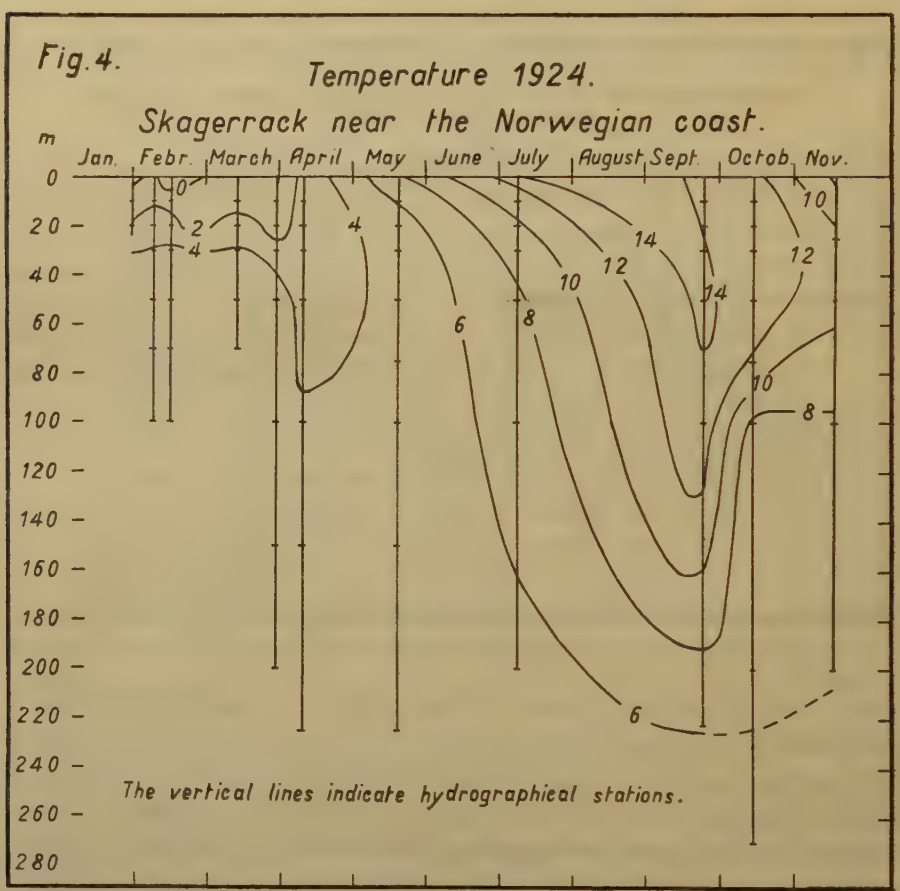
the cod and the appearance of the scales is a very difficult one in our case.

In fig. 4 I have given some temperature measurements from the coastal waters in 1924. The winter temperatures are somewhat below normal, but this is of no importance in relation to the great seasonal changes. Fig. 5 gives the surface temperature at Torungen, the outermost island at Arendal, and the temperature of the sea-water 1 and 15 m below the surface at Flødevigen (in the skjærgaard).

The highest surface temperature at Torungen (and at Flødevigen at 1 m) occurs normally between 15th July and 15th August. At 15 m the summer maximum occurs one month later (about 1st September) and in the deeps off the coast apparently towards the end of September On the 5th October, 1927, I found a value as high as 11 °C at 150 m. This illustrates the well-known fact that the summer season occurs later and later as we proceed from the surface into the depths. Looking at the minimum temperatures we find just the same.

Table I, pages 88—91, furnishes information on the temperatures etc. in the fjords.

Tab. 1 A. contains the measurements for the inner part of the Søndeledfjord, the Rødsfjord, situated near the locality from which the cod are collected. At a depth of 45 m and below, the seasonal

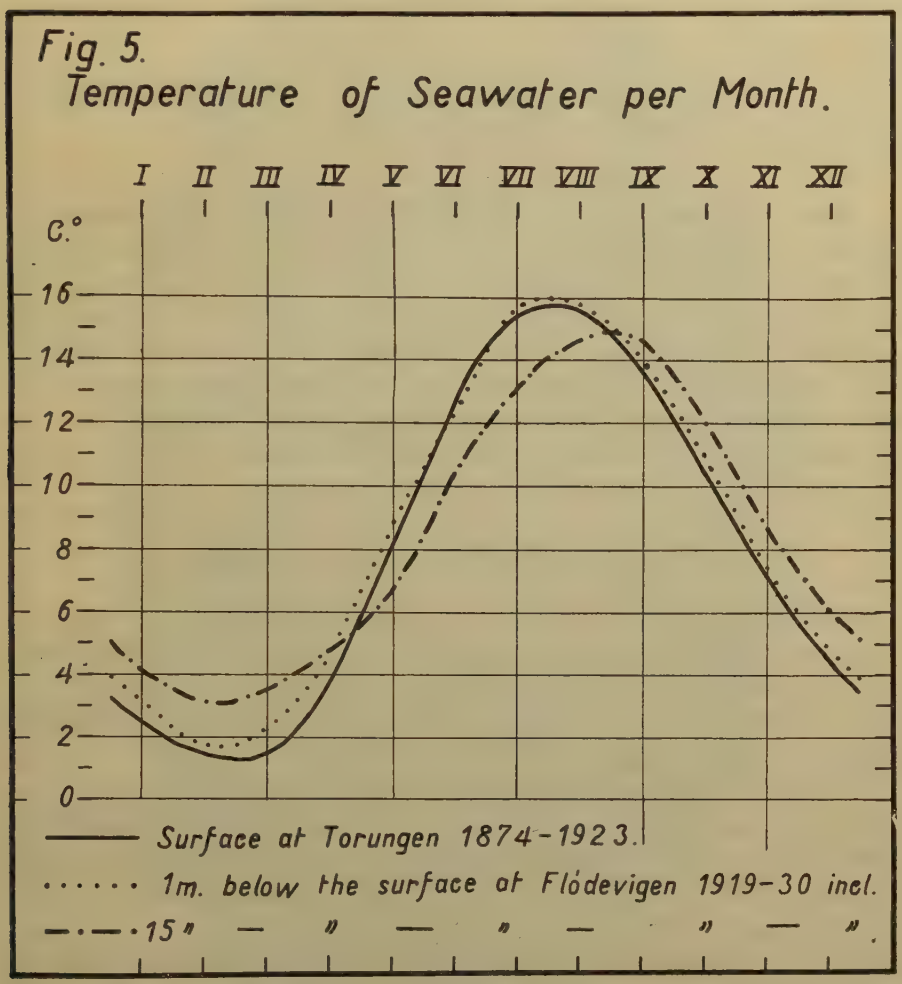


changes, if any, are very slight. We find the highest temperatures at 25 m in September, while at 35 m they occur in December. The observations however, are scanty. The low oxygen values occurring in certain seasons from 35 m downwards indicate that the water is stagnant.

Table 1 B. for the Topdalsfjord, and table 1 C. for the Kristiansandsfjord, give the measurements on either side of the area from which the cod material is collected in that district. In the inner part of the Topdalsfjord the temperature at 40 m varies by only a few tenths of a degree; at 30 m, however, seasonal changes occur, with the higest temperatures apparently between September and November.

No observations were made during the winter. From November to April or May both the Søndeledfjord and the Topdalsfjord are covered with ice.

In the three years referred to, the quantity of oxygen in the deep layers must surely have affected the depth at which the cod lived in



those fjords. A shortage of oxygen in the deep layers will compel the fish to seek the shallow waters.

In the Kristiansandsfjord, outside the entrance to the Topdalsfjord, seasonal changes occur at 100 m to a limited extent, and even at 125 and 150 metres, with the highest temperatures in autumn and the lowest apparently in early summer. The water here is well ventilated. The salinity in the fjords is relatively low near the surface, but increases quickly with the depth.

III. The age and growth of the cod living under natural conditions.

The cod from the Norwegian Skagerrack coast have previously been investigated and reported upon by Hjort and Dahl (1900) and by Dahl, K. and Dannevig, G. M. (1906). In order to study the growth of the cod the former investigators used the method of Dr. Petersen measuring a large number of fish at different seasons. This was also done by Dahl and Dannevig for the young fish, but Dahl also used the scale and otolith method for determining the age of the older fish.

The results obtained by the different investigators will be referred to later, when our own material has been discussed.

A. The occurrence of zones in the scales.

As mentioned in the preface, the first question which arose in connection with fish living under natural conditions was: at what season are the zones laid down in the scales of the cod in our waters?

In order that the method should not be dependent on personal judgement we first had recourse to sclerite measurements.

Detailed information as to the method of measuring and calculating the sclerites has been given in the paper mentioned above (Dannevig 1925). The breadth of the sclerites in the distal part of the scale is marked off on millimetre paper by the aid of an Edinger projecting apparatus. By this means the sclerites are measured along the radius of the scale, fig. 6. The radius of the scale and the measurements of the sclerites are then (by the method of Lea 1910) raised into a constant ratio to the length of the fish. Previous investigators (Winge 1915, Harold Thompson 1926) have found that the growth of the cod and that of the scale are approximately proportional. On this basis we may determine the breadth of the sclerite corresponding to any stage in the growth of the fish. This operation has been carried out and the results tabulated, the average breadth of the sclerites being given for each centimetre of length of the fish. (The unit = 0.0031 mm).

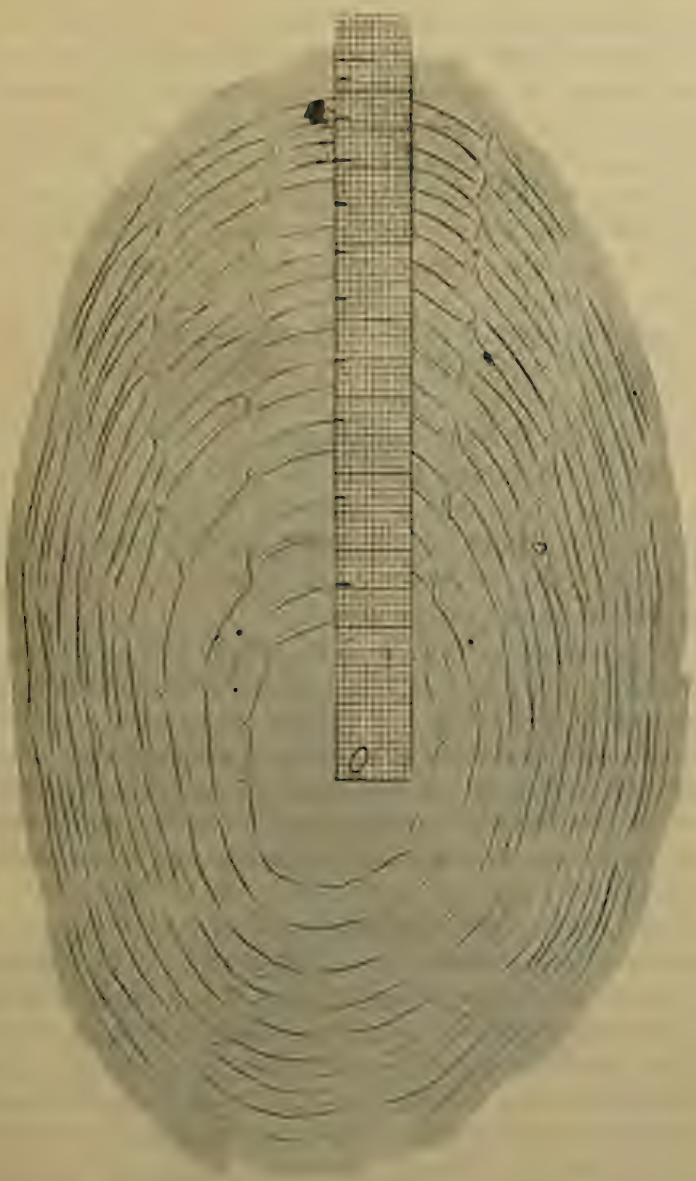


Fig. 6. Scale of cod 9.8 cm. October 11th, 1919.
Enlargement 220 : 1. Illustrates the measurement of the sclerites.

The proportion is not strict, however. The investigations of Duff (1929) seem to show that the growth of the adult cod in Canadian waters is at a maximum during the months of May, June and July, but the scales attain their maximum rate of growth in October. Moreover from a paper by Dannevig and Høst (Journal du Conseil Vol. VI, No. I) it is evident that the computed lengths of the cod (1_1, 1_2, 1_3 . . . .)[1]) will differ according to the part of the body from which the scale is taken. Consequently the growth of the scales cannot be a simple function of the growth of the fish as a whole. For present purposes, however, a linear relation may be assumed without involving serious error. (Graham 1929).

The complete material from the Søndeledfjord in 1927 and 1928, Flødevigen in 1926 and 1927 and the Topdalsfjord in 1926 and 1927 was dealt with in this way. The material from the Søndeledfjord and Flødevigen in 1926 is too scanty, except for the last months of the year, and has therefore been omitted from the tables and graphs.

The question of the time at which the first resting zone is formed was approached by computing the size of the fish when the minimum sclerites appeared on the scales. The tables II A—D, pages 92—95 supply an answer to this question.

The figures in *italics*, indicating the lowest average sclerite breadth for each month, occur as a rule in columns 6—8, indicating that the cod were aproximately 6—8 cm in length when the first resting zone was formed. Measurement of seine-caught yearlings (vide text tab. 2) shows that this length is generally attained in the period July—September. This is in full conformity with the result obtained by myself, (Dannevig 1925), namely, that the first resting zone is laid down in late summer.

The cod caught in the Søndeledfjord in 1927 show the resting zone to have been formed as a rule at calculated lengths of 6 and even 5 or 4 cm. This is a point of great interest. The majority of the cod caught in the Søndeledfjord in the year mentioned seem in this way to have lived under specially unfavourable circumstances during the first months of life, or else the first resting zone has been formed at an earlier date than in the cod from the other localities.

This highly important problem will not, however, be dealt with in the present paper. As shown by Dannevig and Høst (1931) scale material for such an examination must be collected with special care. A scale from the posterior part of the fish will give a far greater 1_1

[1]) 1_1 means the calculated length of the fish at the time of formation of the first resting zone, 1_2 of the second, and so on.

Tab. 2. Codling caught in a fine-meshed seine near shore in the Søndeledfjord.[1])

	1904		1905	
Cm.	25/7—3/8	19—26/9	29/7—12/8	20—28/9
3.....	4	—	—	—
4.....	123	1	33	3
5.....	747	4	144	10
6.....	**992**	36	312	70
7.....	674	223	**314**	171
8.....	513	**406**	137	**217**
9.....	226	340	84	202
10.....	68	209	43	178
11.....	184	98	24	90
12.....	246	64	20	43
13.....	167	46	28	26
14.....	107	35	26	32
15.....	54	45	23	24
16.....	21	34	20	23
17.....	13	18	20	27
18.....	7	14	12	25
19.....	10	6	22	22
	4156	1579	1262	1163

than a scale from the anterior part. When the collection of this material was begun, I was not aware of this fact, and the samples have not been taken from the same part of the fish in all cases. In the Søndeledfjord and at Flødevigen the samples were taken under the 2nd dorsal below the lateral line, and at Topdalsfjord under the 1st dorsal above the line. This would suggest that the first zones in the scales from the Søndeledfjord have given relatively high values for 1_1.

From the same tables II A—D it will be seen that maximum sized sclerites (heavy figures), as shown by the average values, are first formed at a length from about 11 to 20 cm or more, that is, during autumn, winter and spring. We must, however, take into consideration the fact that we are dealing with average values. If we have to do with both slow- and quick-growing cod with relatively small and large sclerites, as we certainly have, the actual occurrence of maximum sclerites of the individuals may be obscured. We have not, therefore, thought it safe to continue to observe the occurrence of maximum or minimum sclerites in the same way as is used when locating the first resting zone. It will be evident that in the case of the first resting zone the difference in growth-rate is not likely to be of any great significance.

[1]) Dahl, K. og Dannevig, G. M. 1906.

The next question considered was: At what time of the year are the zones of small and of large sclerites formed at the margin of the scale? From the sclerite curves previously referred to, the width of the sclerites near the margin of the scale was found for each centi-

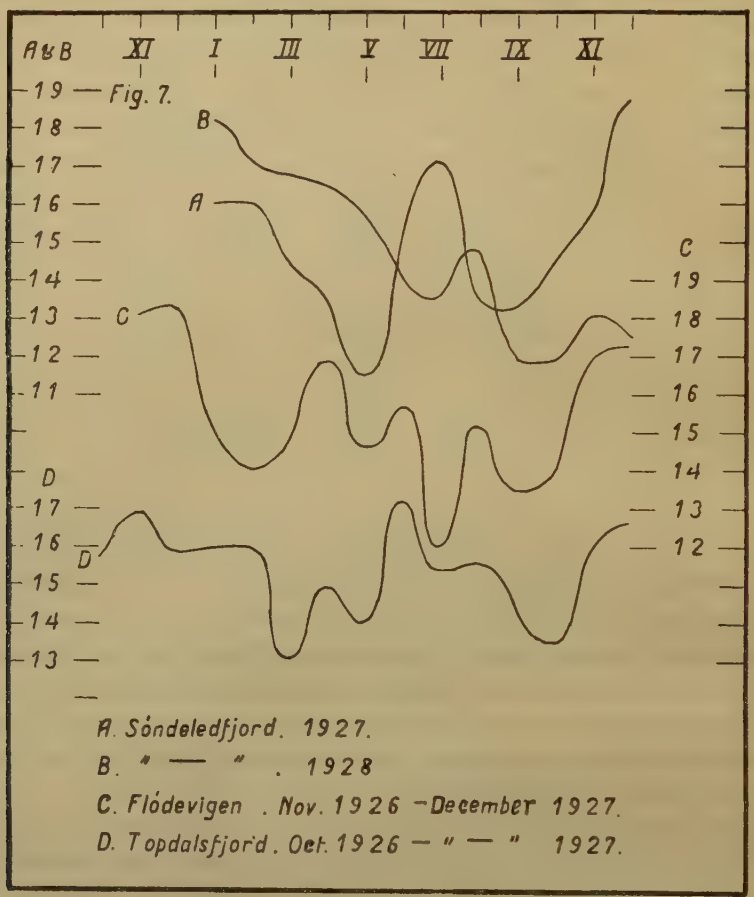


Fig. 7. Average width of sclerites at a distance from margin of the scale equal to one centimetre growth of the fish. (Column I of Table III A—D.) Cod less than 40 cm in length.

metre of computed length of the fish. The results are compiled in tables III & IV, pages 96—103; column O giving the average width of the sclerites at the very margin of the scale, column 1 at a distance equal to a calculated growth of 1 cm of the cod, and so on. As it is to be expected that the process of spawning might affect the formation of the zones in the scales, we have treated the young cod separately.

Table III deals with fish of less than 40 cm; these have never spawned. Table IV deals with the bigger ones, but among them may also be several immature fish.

A glance at column 0, table III (cod less than 40 cm) at once reveals the fact that the size of the sclerites varies considerably, but as the last sclerites may not have finished their development we ought rather to look at column 1. These sclerites have been formed only a short time previously, and may be considered as nearly completed. If the cod grows about 12 cm a year (as in fact it does in the age groups considered) the time elapsed, after the formation of the sclerites indicated in column 1, will be about one month.

Fig. 7 shows the values from the three localities, Søndeledfjord, Flødevigen and Topdalsfjord, for the year 1927, and Søndeledfjord also for 1928. It is evident that the size of the sclerites near the margin varies a good deal during the year, and the first glance gives no suggestion of regularity of manner.

There are great differences between the figures for the three fjords and between the results for Søndeledfjord in 1927 and 1928. No two curves are alike, though those based on data from Flødevigen and Topdalsfjord agree best.

We may, however, note the following points:

1. During the period August—October all curves show one distinct minimum.
2. Minima occur in other seasons also, e. g., in spring and summer.
3. All curves, except that for Søndeledfjord in 1928, show high average values during late autumn or early winter.
4. High values are also found in summer.

For 1928 we have measured the sclerites of the cod from the Søndeledfjord only. The results are quite different from those of the previous year, as maximum values do not appear in the autumn. Though it would be of interest to elucidate this point further, for the present we must postpone consideration of the question until data bearing upon it can be collected, the method used hardly being adequate.

The differences between the sclerites in different specimens are greater than those found between the sclerites of a single scale; the mean size of the sclerites may thus be very much influenced by the relative number of cod having large or small sclerites. As it seemed that this phenomenon might conceal the normal variation in the size of the sclerites of each individual, this method was given up.

The data for fish longer than 40 cm. (Tab. IV A-D) are rather scanty. It is indeed scarcely possible to obtain a sufficient quantity

of grown cod from these waters since the cod is "harvested" at a very small size.

The curves for column 1, Fig. 8, are very difficult to comprehend. I am inclined to believe that the cause of the great irregularity is the occurrence of spawners and immature fish in the same sample.

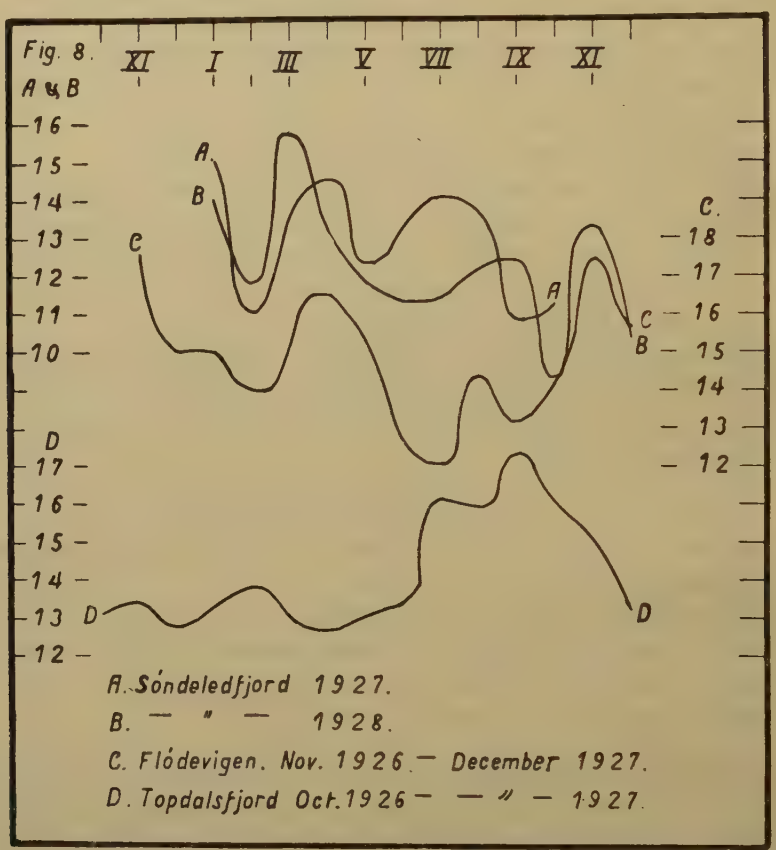


Fig. 8. Average width of sclerites at a distance from margin of the scale equal to one centimetre growth of the fish. (Column I of table IV A—D.) Cod 40 cm or more in length.

It may be that the spawning process will influence the growth of the scale and the season of the formation of the zones. Nevertheless several points of agreement are to be found also here, especially between the curves A, B, and C. We have distinct minima in February, in September and in October. The curve from Topdalsfjord shows just the opposite.

Before leaving the sclerite measurements attention must be drawn to the occurrence of maximum sclerites *for each month of the year*, the values here being computed, as averages, from the same individuals. In tables III & IV the maximum and minimum values are found near the margin in one month, in the next month they are found at a distance from the margin, and so on. In this way we are able to trace in some cases, as for example in tab. III B & III C the minimum or maximum sclerites from month to month along an oblique line. In the tables the significant figures are in heavy or sloping type, but, as will be seen, the method is open to objection on the ground that slight maxima or minima also occur outside the line. It will nevertheless yield some information as to the season when the different zones are formed at the margin of the scale. The fish from Søndeledfjord in 1928 show large sclerites at the margin in January. During February and March the maximum sclerites are at a distance corresponding to 2 cm body-growth from the margin, in April 3 cm, in May 5 cm, in June 5—6 cm, in July 7 cm. The occurrence of minimum sclerites is not so regular.

Passing to the material from Flødevigen, Tab. III C, large sclerites are found near the margin in November—December 1926 and they gradually retreat from the margin, to a distance corresponding to 9 cm of growth, in the month of June. Small sclerites are found near the margin in August-September; these also withdraw from the margin.

The material from the Topdalsfjord, Tab. III D, is very similar, but in this case attention may be especially directed to the large sclerites which occur near the margin in June. The summer maximum is very distinct.

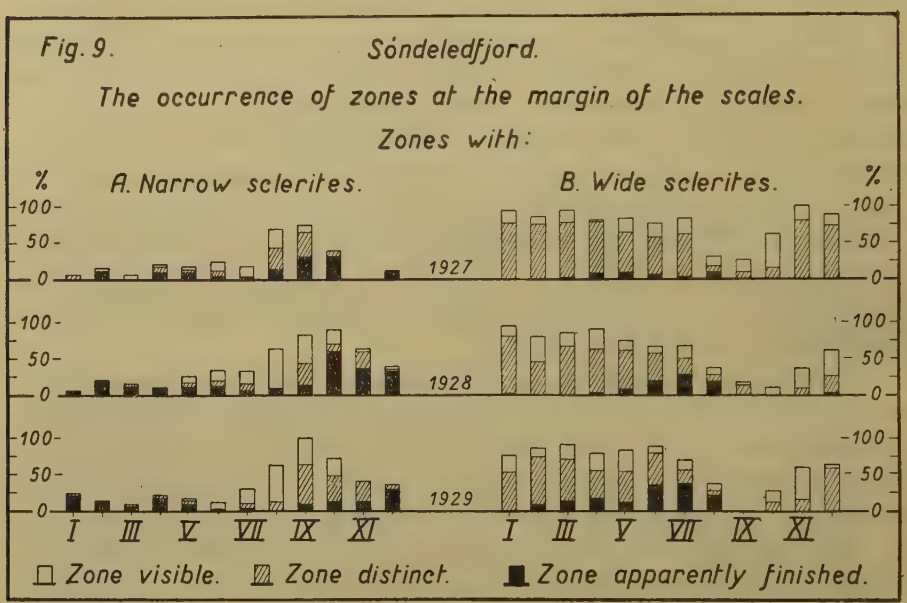
The material from the Søndeledfjord in 1927 is not homogeneous enough to follow the values in this way at any distance from the margin.

Tables IV A—D give the sclerite widths for cod over 40 cm in length. The material is very sparse and also difficult to comprehend.

From these investigations we get an indication that, for immature cod, the chief season for the formation of small sclerites is late summer and for large sclerites late autumn and early winter.

In order to approach the problem still more closely, it was necessary to study the scales of the single specimens individually. This was done with the material from the Søndeledfjord for 1927—1929. The cod scales were examined under the microscope, and the edge characterized by the letters „w" or „n" according to whether "wide" or "narrow" sclerites were present. If the zones of w or n sclerites were broad, they were called "distinct" or "apparently finished". The results are given in fig. 9.

Scales with narrow sclerites at the margin are found in all months of the year, the percentage being highest in August to October. August is the principal time for the formation of new zones, by September most of the scales already have distinct zones and in December most of the narrow zones near the margin are apparently completed. Zones with broad sclerites predominate from November to July.



Now the question arises as to whether the zones formed in other seasons are supernumerary, secondary zones, or of the same significance as the zones formed in the main season.

The question may be stated in another way. Do the cod regularly acquire one zone a year, in somewhat different seasons, or do they all acquire one zone in the main season and a second, perhaps less marked, in another? As will be seen from figure 9, the great majority of cod scales (100 % of them in one case) in the months of August, September and October have narrow zones at the margin. This makes it reasonable to assume that the great majority of the cod form their narrow sclerite zones in the season mentioned, and that the narrow zones found near the margin in other seasons must be supernumerary.

Workers dealing with cod scales have often been troubled by these secondary zones. It is impossible from a mere inspection of the scale, to distinguish the secondary minima from the true resting zones.

Fig. 10 a. Typical scale of Cod (× 20). J. no. 383, 30/4, 1920. Length 65 cm. The zones are difficult to decipher. In correspondence with the otolith (Fig. 10 b) 5 zones with narrow sclerites may be counted.

Graham (1928) has paid great attention to the problem, and in order to avoid the influence of a subjective opinion on the matter, he has worked out an objective method by which it is possible to make out the most prominent zones by formulae based on sclerite measurements. By means of examples he shows that the method works well on the material examined, giving the true age of the most prominent groups. This method has also been tried by us, and the results are given below.

The results of our study of the scales from the immature cod may be summarized thus:

The sclerite measurements, show that the size of the sclerites at the margin of the scale varies from month to month, but there is also some difference when comparing the figures for different waters and different years.

Though it is not possible to fix accurately the season of the formation of narrow or wide sclerites, we may learn that in the material examined small sclerites are relatively very frequent in late summer, which appears to be the main period for the formation of zones in the scales. But small sclerites also occur in other seasons, especially in early spring and summer.

Subjective inspection of the scales shows that zones with narrow sclerites are occasionally found near the margin of the scale throughout the whole year, but it is evident that the highest percentage of fish with scales having narrow sclerites on the margin is found in the months of August and September.

As a result of the investigations described, some error in computing the age of the cod from these waters by the scale method is to be expected on account of the secondary zones.

B. The occurrence of zones in the otoliths.

As a further step in the solution of the problem of age-determination we proceeded to study the otoliths in the possibility that their zones were of a more definite nature and would provide a check to the zones in the scales.

The otolith method for determining the age of the cod has been in use for more than 25 years, but — certainly on account of missing investigations — there is in the literature some divergence of opinion as to the season when the different zones are formed. I therefore considered it essential to study the material from our waters with this problem in view.

The otoliths from young cod, when fresh or properly preserved, are generally transparent enough to show the zones without any

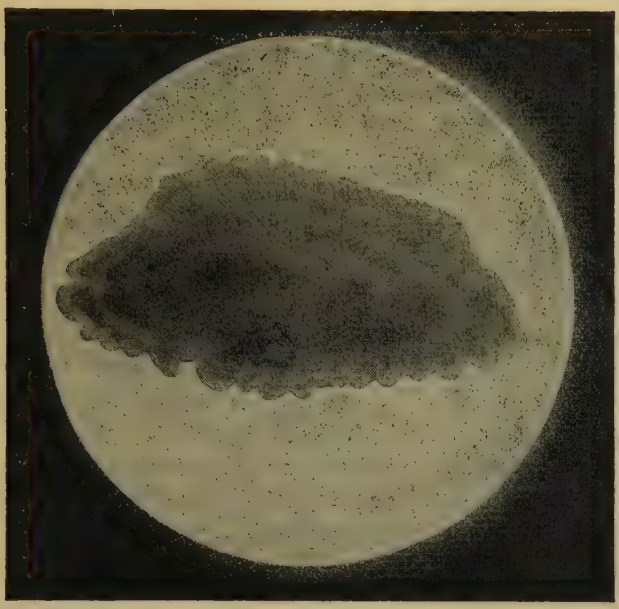


Fig. 10 b. The total otolith (× 4) photographed in Edingers Projection Apparatus. From the same fish as fig. 10 a.

Fig. 11 Transverse cut of otolith (× 8). Cod 74 cm, J. no. 105, 5/8, 1920.

further preparation. But as it may happen that a zone may escape detection in this way, they are always broken across, and the original result is verified on the transverse surface. Otoliths from older fish must always be broken across, and the surface is, when necessary, ground on a rotating carborundum grinder moistened with glycerine and afterwards polished on a very fine grindstone. The whole process of grinding and polishing a big otolith is performed in a few minutes. In some cases thin sections similar to those made from rock specimens are prepared. (Fig. 11).[1])

The otoliths are examined with a low power lens in good daylight and the transparent zones which are clear in transmitted light, dark in reflected, are counted. The character of the zone at the margin, as it appears in the transverse surface, is also noted.

Such an investigation has been carried through on the cod from the Søndeledfjord for the years 1923—1929 (Fig. 12) and on those from the Topdalsfjord for the years 1924—1929 (Fig. 13).

From fig. 12 (Søndeledfjord) we see that the percentage of otoliths with transparent zones at the margin reaches its highest value in the months August to October and in 5 out of the 7 years 100 % is reached. At the beginning of the period mentioned we find the transparent zone near the margin of the otoliths, as "zone visible" and "zone distinct". In the latter part of the period otoliths with "zone finished" predominate.

Similarly it is evident that opaque zones occur near the margin in practically 100 % of the cases during the period December to May. The main period for the formation of a new opaque zone is from November to January.

As might be expected, some variation from year to year exists. It is to be assumed that the conditions of life, especially the temperature and food, may be influential in this respect, and we have in addition the variation introduced by the method, the results being based entirely on subjective observations.

In fig. 13 the material from Topdalsfjord is arranged according to age. This was done in order to discover whether the season of the formation of the zones in the otoliths varied according to the age of the fish. The material is arranged according to the calendar

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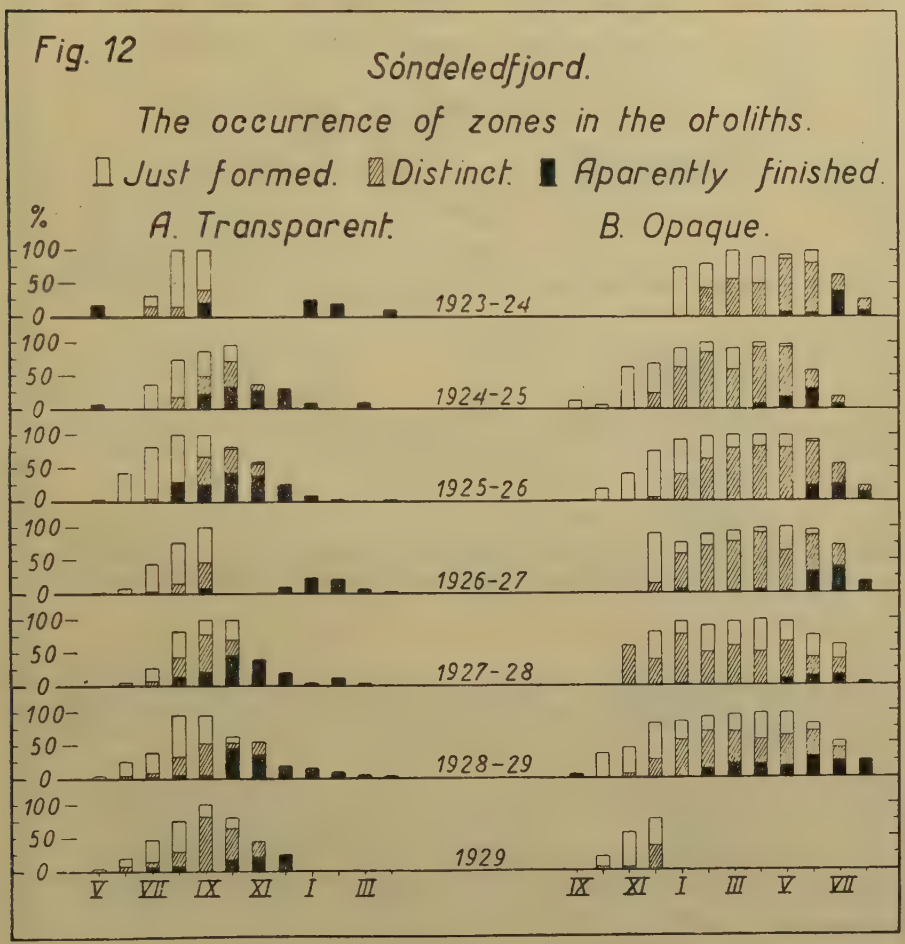
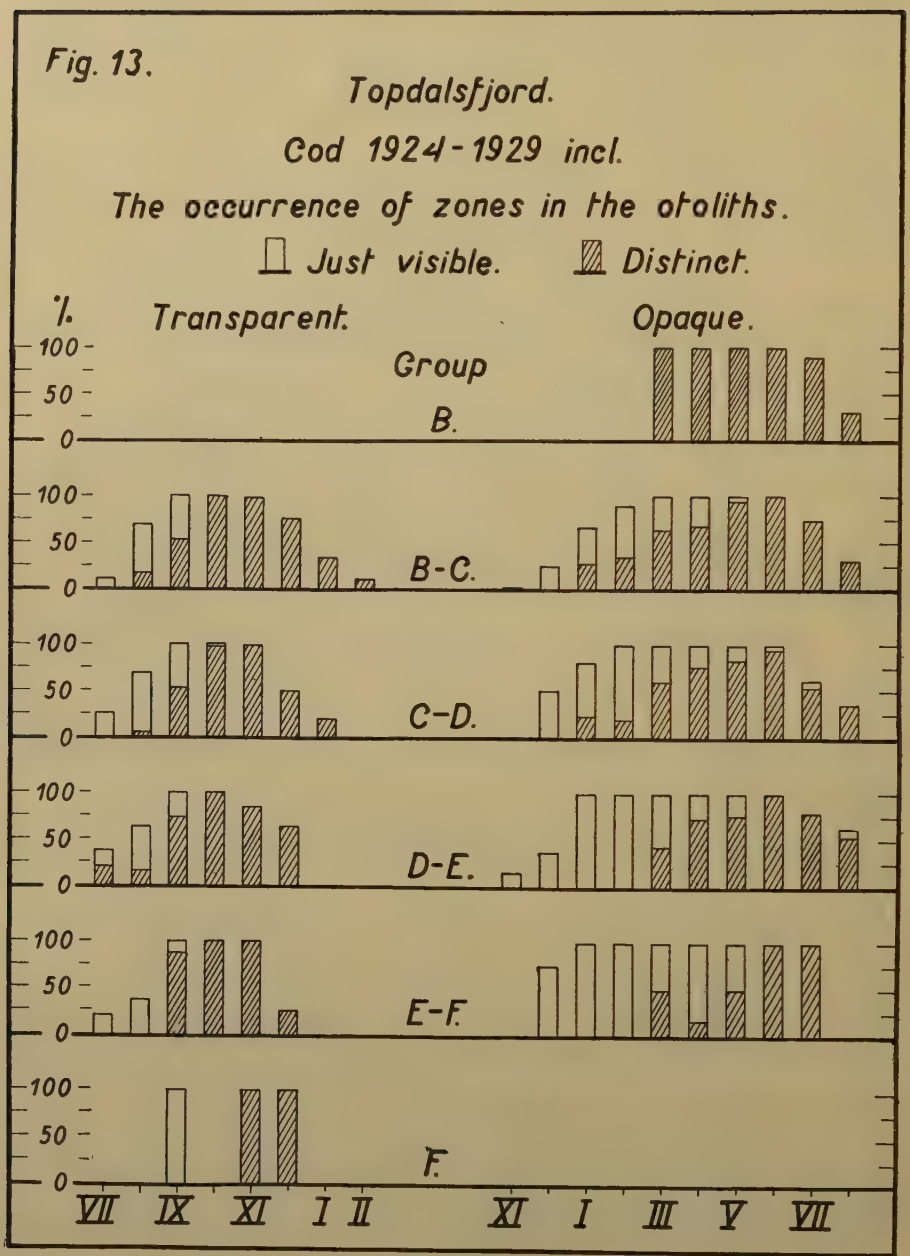
[1]) If the otoliths are not examined fresh, they are put (together with the scales from the same specimen) in small glass tubes (12 x 50 mm) which are half filled with a mixture of: Glycerine 50 cm³, water 45 cm³ formalin 5 cm³. This mixture keeps the otoliths transparent. In some years 10 % of a concentrated watery solution of acid fuchsine was added. A cotton stopper is put in the tubes which are arranged in numbered holes in square boards each taking 200 tubes.

year:—Group A consisting of fish caught in the year when hatched, Group B fish caught the year after, and so on. The common method of grouping the fish according to each full year of life, Gr. 0, Gr. 1 etc., involves the supposition of a common hatching time. As the spawning



period may cover quite a long time in our waters, we have preferred to use a less prejudicial grouping.

The figures for Topdalsfjord are more compact than the figures for Søndeledfjord. In the former series only 4 different terms were used, in the latter 6. It appears that the difference between the age-groups, if any, is very small. The completed opaque zone seems to predominate from March to July, the transparent zone from September to November.



The investigation justified the opinion that the zones in the otoliths are formed annually.

It will be noticed that the formation of zones in the otoliths is of a far more regular nature than in the scales. Since the formation of

transparent zones is restricted to a relatively short season, there is in consequence hardly any opportunity for secondary zones to be formed. The otoliths offer a safe foundation for age-determination at least in young fish. When dealing with an unfamiliar material it is, however, of importance not only to count the zones, but also to note the nature of the margin and to draw graphs to ascertain the seasons in which the different zones are formed.

Fish in their first year are not represented in the material from the traps. Yearlings were therefore caught in nets and preserved in spirit or formalin for later examination. The otoliths, however, had not kept well and were unfit for use in the investigation. Fresh material was, however, collected in the bay at Flødevigen on the 12th of August 1930.

The data from this sample were:

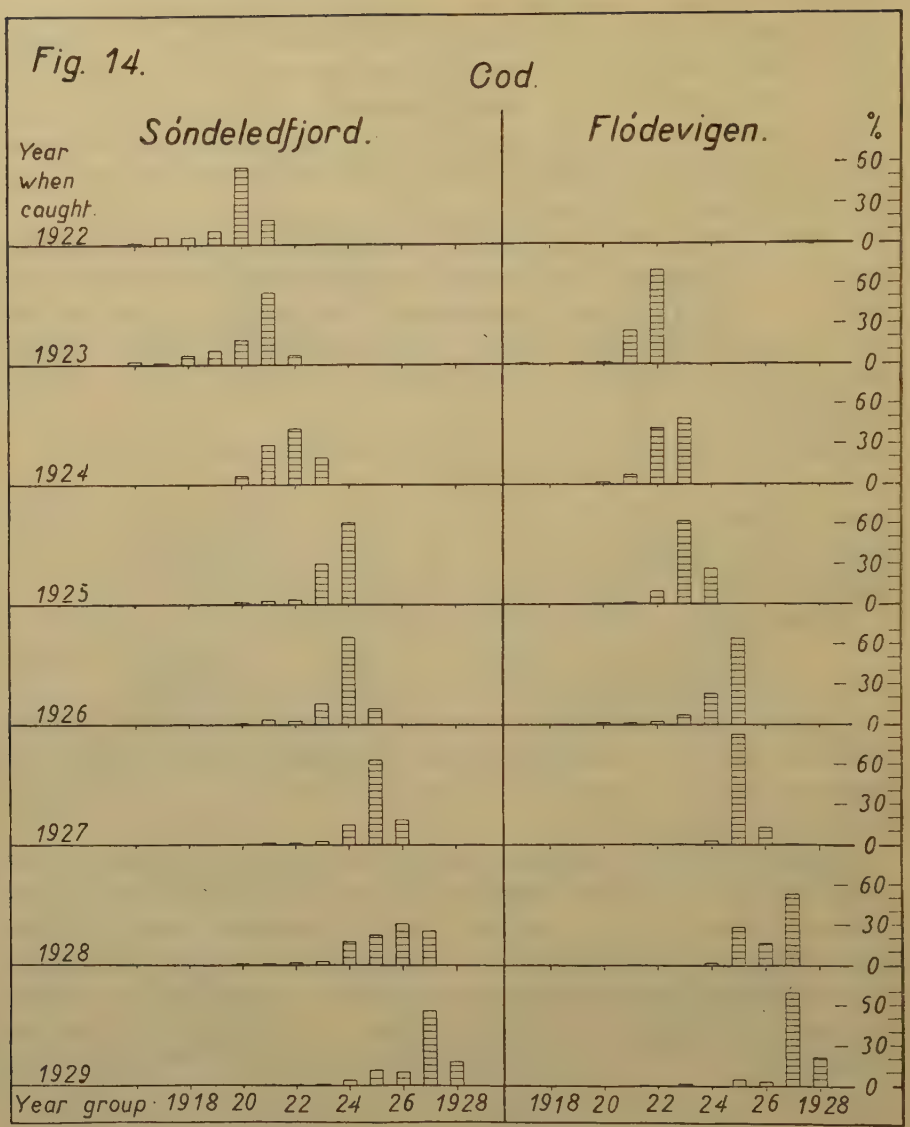
Length of cod	7	7·5	8	8·5	9	9·5	10	10·5	11	19 cm.
Number	1	1		3	5	1	7	6	8	1

Examination of the otoliths gave the result that the cod from 7—11 cm showed one transparent zone close to the margin, the specimen of 19 cm 2 zones, the last one lying on the margin.

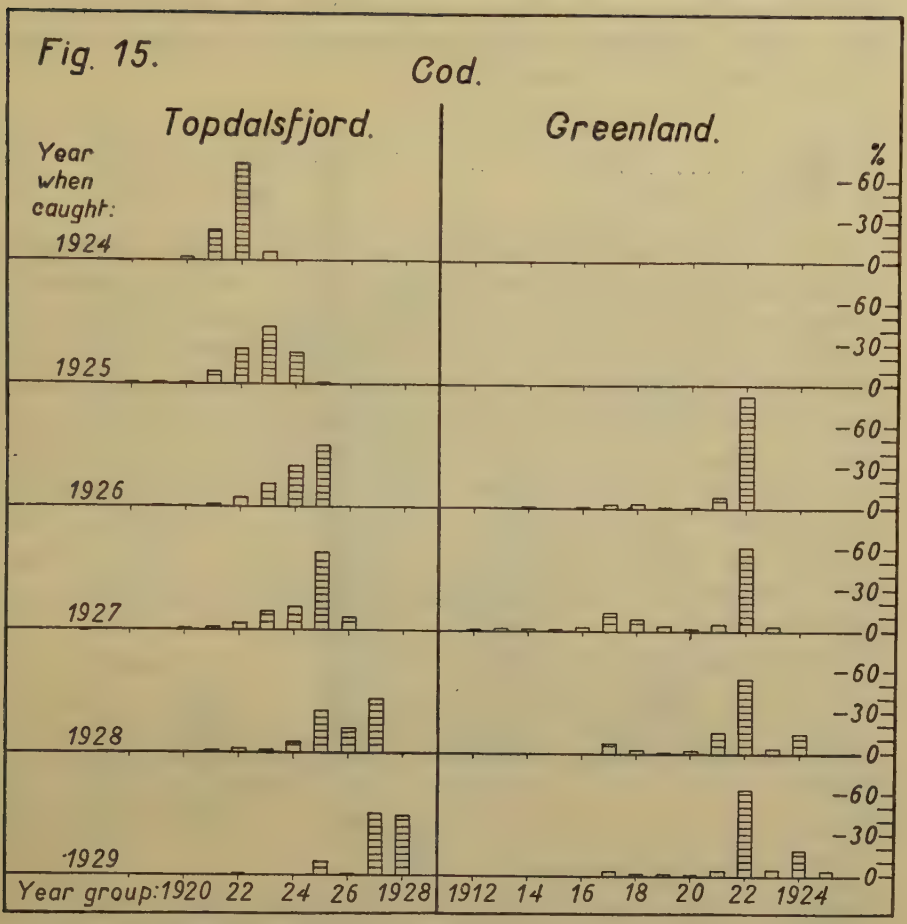
This is in full conformity with the findings for the older fish, and also with the great number of observations which I have made when examining the cod during my cruises. The cod from 7—11 cm belong to the 0 or A group.

The simplicity of reading the otoliths may be illustrated by the following example. Miss Mathisen and Mr. Sørensen made independent examinations of the otoliths of the cod caught at Flødevigen from January to April 1930 and of the large cod used for the Hatchery. In all, the otoliths from 436 cod were examined. In one of the otoliths the zones could not be made out. One of the observers considered the otoliths from two individuals to be uncertain, but the ages estimated were the same as those arrived at by the other observer. In one case only the ages estimated differed by one year. The ages of the fish examined were between 1 and 10 years.

Although figures 12 and 13 cannot be explained otherwise than that the zones in the otoliths are annual, we will attempt to establish this point by means of the material at our disposal. This should be possible if the material is collected for several years in succession, and if the different broods vary in number and are permitted to grow up for some years. The clearest demonstration of the validity of this method of age-determination is given in the case of the herring by



Einar Lea (1919), who traced the dominant 1904 year-class for many years. Our material is not adaptable to this end as the cod is "harvested" as soon as it reaches marketable size. The cod in the market is generally in its second or third year only. But by looking at figures 14 & 15 it will be evident that relatively strong year-classes can be traced for some years. In the Søndeledfjord the 1924 year-class predominates for two years, in the Topdalsfjord the 1925 year-class is predominant, also for two years; and the same is the case at Flødevigen.



The otolith method is used in Iceland and in the Danish investigation of the cod at Greenland. From the paper by Ad. S. Jensen and Paul N. Hansen: "Undersøgelser over den grønlandske torsk" I have taken some figures, reproduced in my fig. 15. The predominance of the good 1922 year-class for several years is in itself a justification of the method used.

C. A comparison of the scale and the otolith method.

Although our investigations indicate that the otolith method is to be preferred to the scale method for computing the age of cod from our waters, it will be of interest to compare the results given by the two separate methods. The age of the cod caught in the Søndeledfjord

in 1928 was computed by the otolith method, and also by Graham's scale method ("Studies of Age-Determination in Fish" Part I, 1928).

The results are as follows:

Brood:	1920	1921	1922	1923	1924	1925	1926	1927
By otoliths:	2	2	4	9	86	108	159	130
By Grahams method:			3	12	59	113	179	134

The chief results are the same by both methods; the relative strengths of the different broods correspond. There is, however, a general tendency for Graham's method to give lower ages than the otoliths, i. e., zones are lost. In the case of the older fish Mr. Graham makes a reservation on this point, not having had sufficient material at disposal. Possibly the method might be altered to fit our material better, but as it is very laborious, we made no attempt to this end. The method is, however, of importance for a preliminary investigation of the scales, since it leaves no room for personal bias.

The age of the adult cod from the Hatchery in 1928 was estimated by means of otoliths and scales. The scales were examined under the microscope.

The results were as follows:

Cod from the hatching pond 1928.

Brood:	1917	1918	1919	1920	1921	1922	1923	1924	1925
Otolith:	1	1	5	4	13	60	73	116	18
Scale:				6	10	34	106	120	15

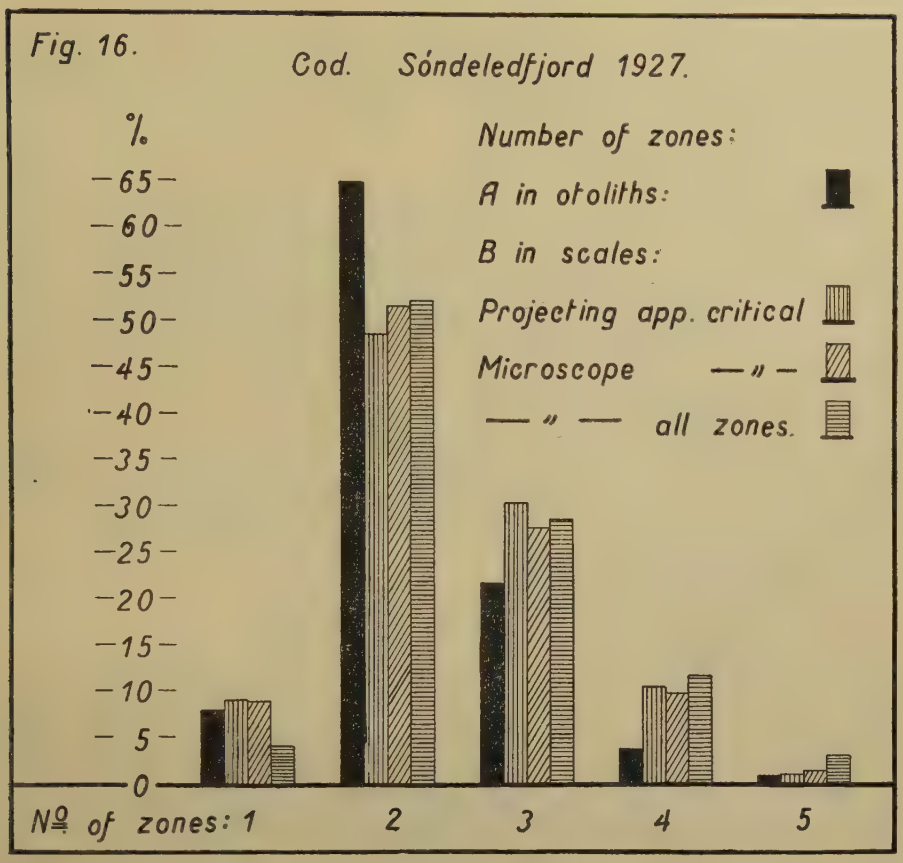
The same in percentages:

Otolith:	0·3	0·3	1·7	1·4	4·5	20·6	25·1	39·9	6·2
Scale:				2·1	3·4	11·7	36·5	41·2	5.2

By the subjective scale method zones escape detection both in the youngest and in the oldest fish. In the case of the old ones it is difficult to make out the zones near the margin of the scale. In the case of the young fish the material is not representative. For the spawning pond we buy all fish, which from their size are judged to be mature, and in this way the quickest growing fish are selected. And as the zones in the scales of the quick-growers may be very faint they may escape the examiner.

In regard to the predominant year-classes, we find that the two methods yield fairly concordant results although there are large divergences.

The age of the cod from the Søndeledfjord 1927 was computed in four different ways.



Cod, Søndeledfjord, 1927.

Number of zones:	1	2	3	4	5	6
a. Otoliths:	37	297	99	18	4	1
b. Scales:						
1. Projecting apparatus, critically:[1]	42	222	138	49	5	
2. Microscope, critically:	41	236	127	45	7	
3. „ all zones:	19	238	131	54	14	

Methods nos. 1 & 2 ought of course to agree; the differences here however, are caused by the difficulty in deciding what is to be reckoned as a zone. The appearance of the zones differs according to the way in which they are examined. For method no. 3 all visible zones are counted, including those taken as secondary in the first two

[1]) Critically ɔ: doubtful zones are excluded.

methods. Thus the fish naturally appear to be older when examined by method no. 3 than by the other methods. From fig. 16, however, it is apparent that by all methods the classes with 2 & 3 zones are the dominant ones.

A comparison of the results obtained from examination of the individual specimens shows that the figures given by the scale method fall on both sides of the otolith readings, and may thus to a high degree eliminate each other. The age of the cod from the Topdalsfjord was calculated both from otoliths and critically from scales, and the divergences of the scale method from the otolith method for each individual are here given.

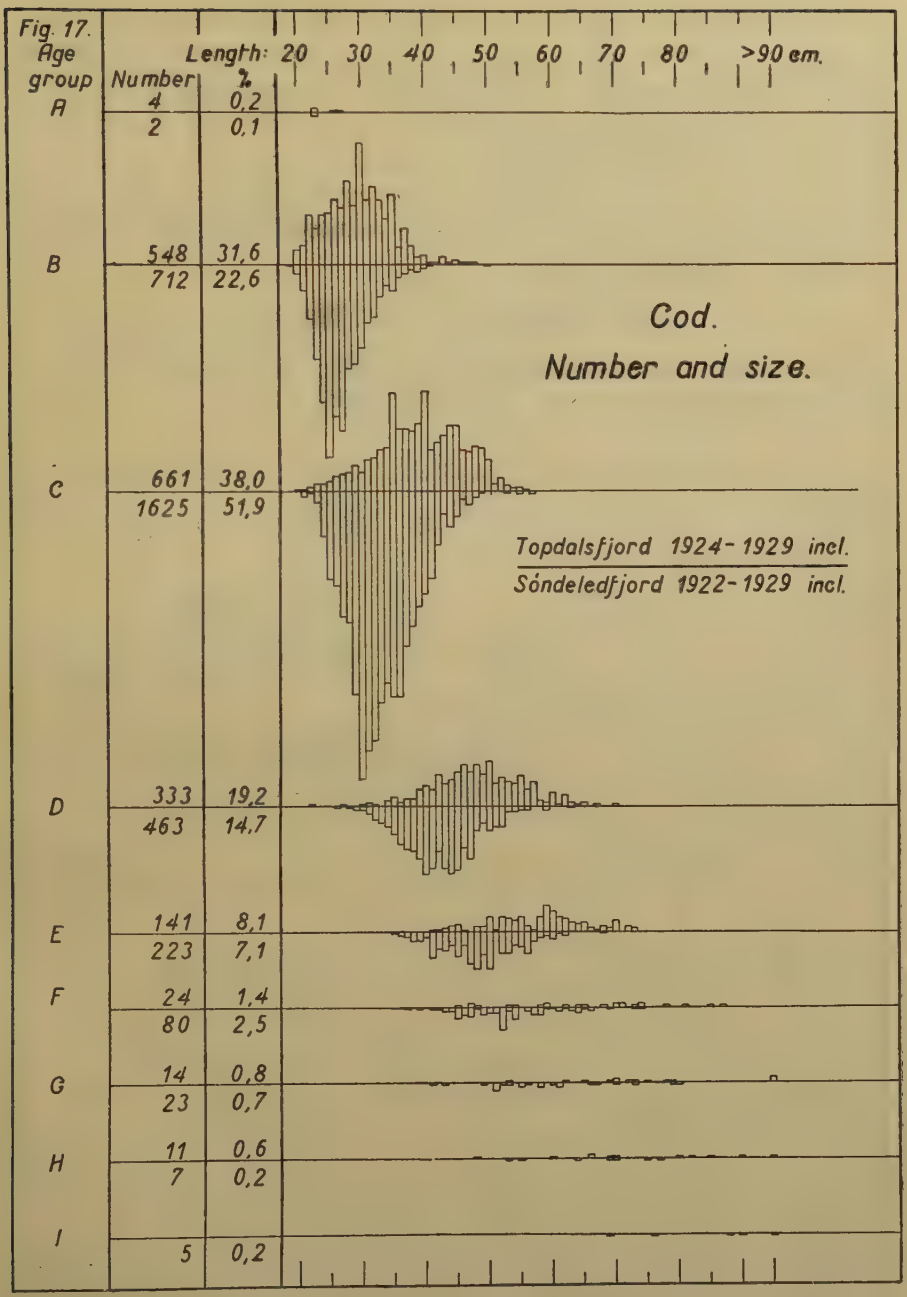
Cod, Topdalsfjord, 1924—1929 (incl.)

Number of zones:	1	2	3	4	5	6	7	8	Total
By otolith method:	145	648	462	222	65	12	8	3	1565
Scale method:									
Individuals with:									
two zones more;.....			2						
one zone more	1	39	34	24	5				
one zone less.....		1	4	9	11	4	2	2	
Total divergences:	1	40	40	33	16	4	2	2	138
Percentage:	0·7	6·2	8·7	12·9	24·6	33·3	25·0	66·7	8·8

It is evident that in the younger fish the scale method has a tendency to give too high values, in the older ones too low. In the first case it is the supernumerary zones (the secondary minima) which disturb the result. With the older fish, zones at the margin escape detection in numbers high enough more than to compensate for the supernumerary zones formed in youth.

The results obtained show that the scale and the otolith methods give the same dominant year-classes for the fish population in our waters. It must be pointed out, however, that we are dealing here with young fish. For adult fish the two methods give divergent results, as we evidently lose sight of zones when using the scale-method.

On the strength of the foregoing section it will be admitted that the otolith method is to be preferred for computing the age of the cod in our waters. The zones are more distinct and the season for their formation is more restricted than in the case of the scales. The actual degree of accuracy of the otolith method cannot be stated on he basis of this material. The example given on page 29 is, however, in favour of the opinion that the reading of the otoliths is correct in nearly all cases, though, especially in old fish, there may be some uncertainty as to the number of zones.



The individuals standing far apart in the tables from their class must naturally be regarded with reserve. In large material errors may occur from erroneous recording or reading.

It is difficult to count the zones of the scales of the cod from our waters and the number of zones found often depends to a large extent upon the caprice of the observer. Nevertheless I am of the opinion that the cod scales would be of very great importance in the study of the life history of the cod in different waters. The structure of the scale is certainly affected by the environment of the fish, and the characteristics of the scale are easily reduced to arithmetical forms.[1])

D. The age and size of the cod.

In tables V—VIII and figures 14, 15, 17, 18 & 20 the results obtained by the otolith method are summarized.

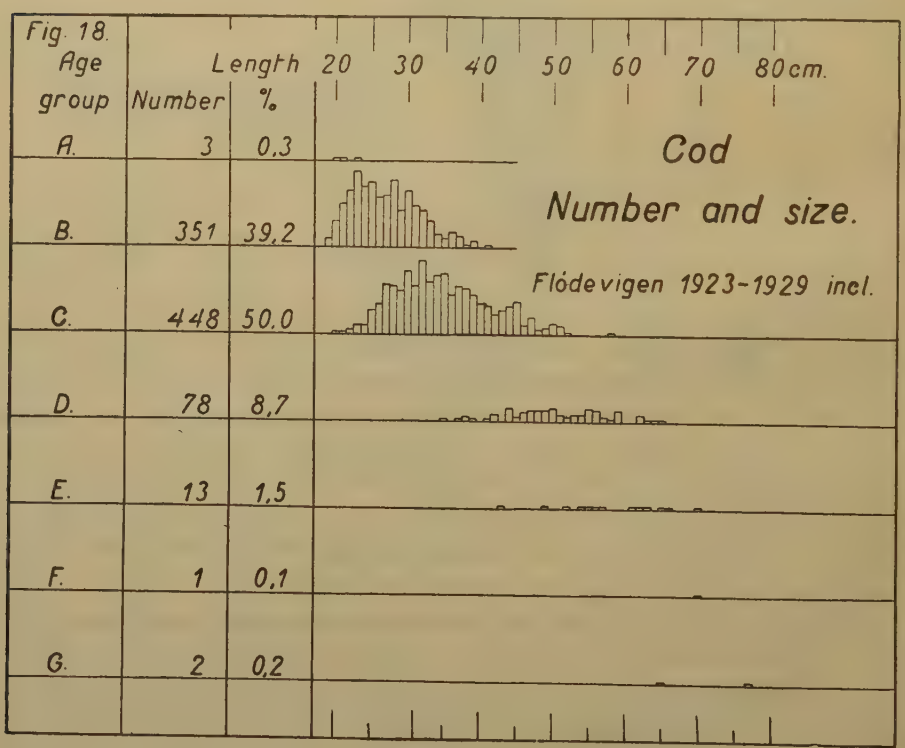


Fig. 17 illustrates the occurrence of the different age groups in the Topdals- and Søndeledfjord. Age group A refers to fish caught in the same calendar year as that in which they were hatched, gr. B. in the next calendar year, and so on. In order to demonstrate the

[1]) Sclerite measurements were first used by O. Sund; vide Hjort, Fluctuations, 1914.

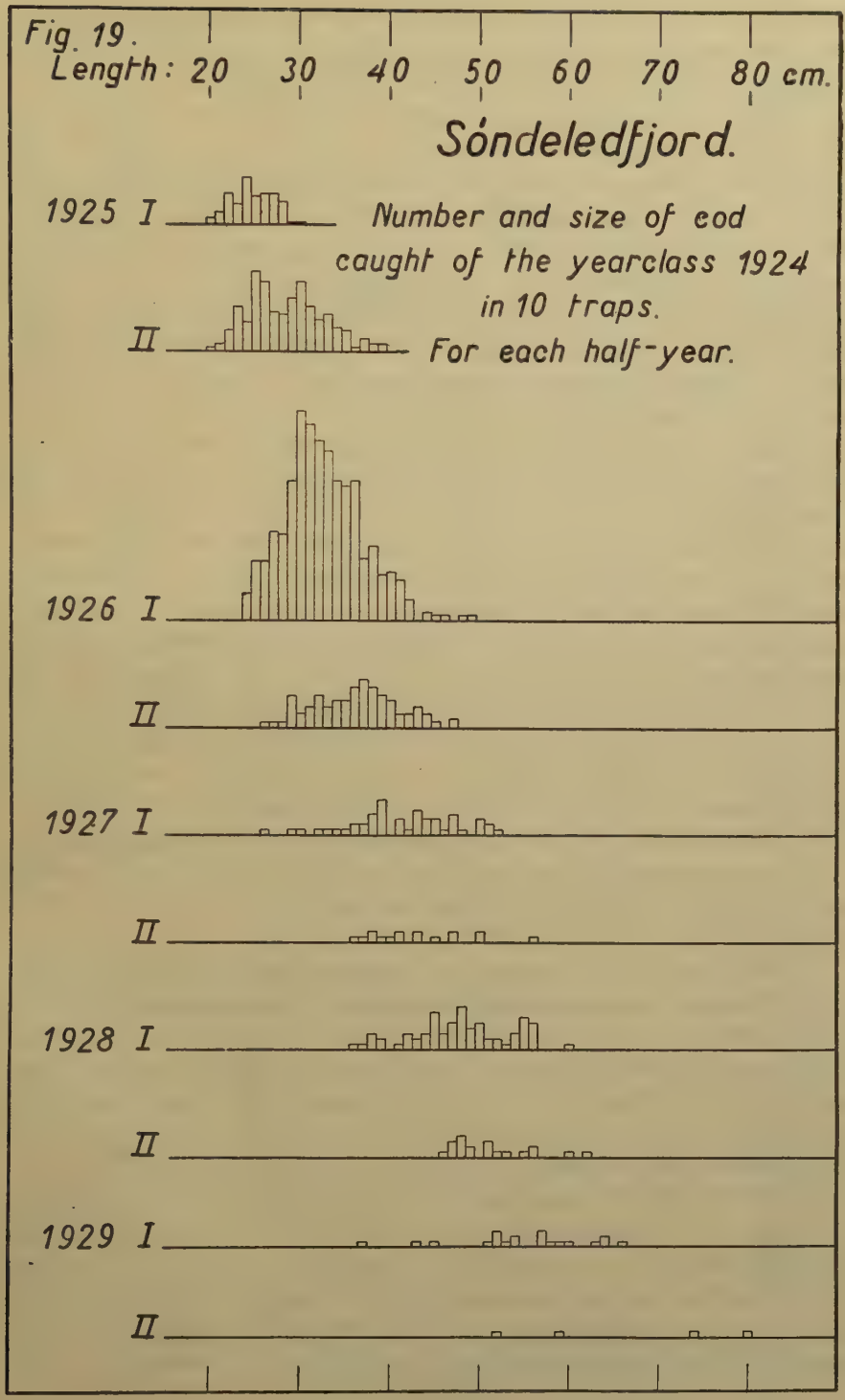


Fig. 19.
Length: 20 30 40 50 60 70 80 cm.
Sóndeledfjord.
1925 I
II
Number and size of cod caught of the yearclass 1924 in 10 traps.
For each half-year.
1926 I
II
1927 I
II
1928 I
II
1929 I
II

different growth rates of the cod in the two fjords the material for the same age is entered on the same abscissæ, the material from the Topdalsfjord above, and from the Søndeledfjord below.

Fish of group A are practically absent from the catches, being too small to be caught. For this reason the average size of the fish in group A, and to some extent also in group B, is not representative.

Group B is very numerous, making up 31.6 & 22.6 % respectively of the whole material from the two fjords, while 38.0 % & 51.9 % belong to the C group. In the Topdalsfjord 69·8 % and in the Søndeledfjord 74·6 % of the cod caught are less than 3 years of age. Fish 5 years of age or more are rare. From fig. 18 it is evident that the relation between the different groups is also the same in the waters near Flødevigen.

Fig. 19 shows the fate of the 1924 brood in the Søndeledfjord. After the first half of 1926 there were practically no fish left of that year-class.

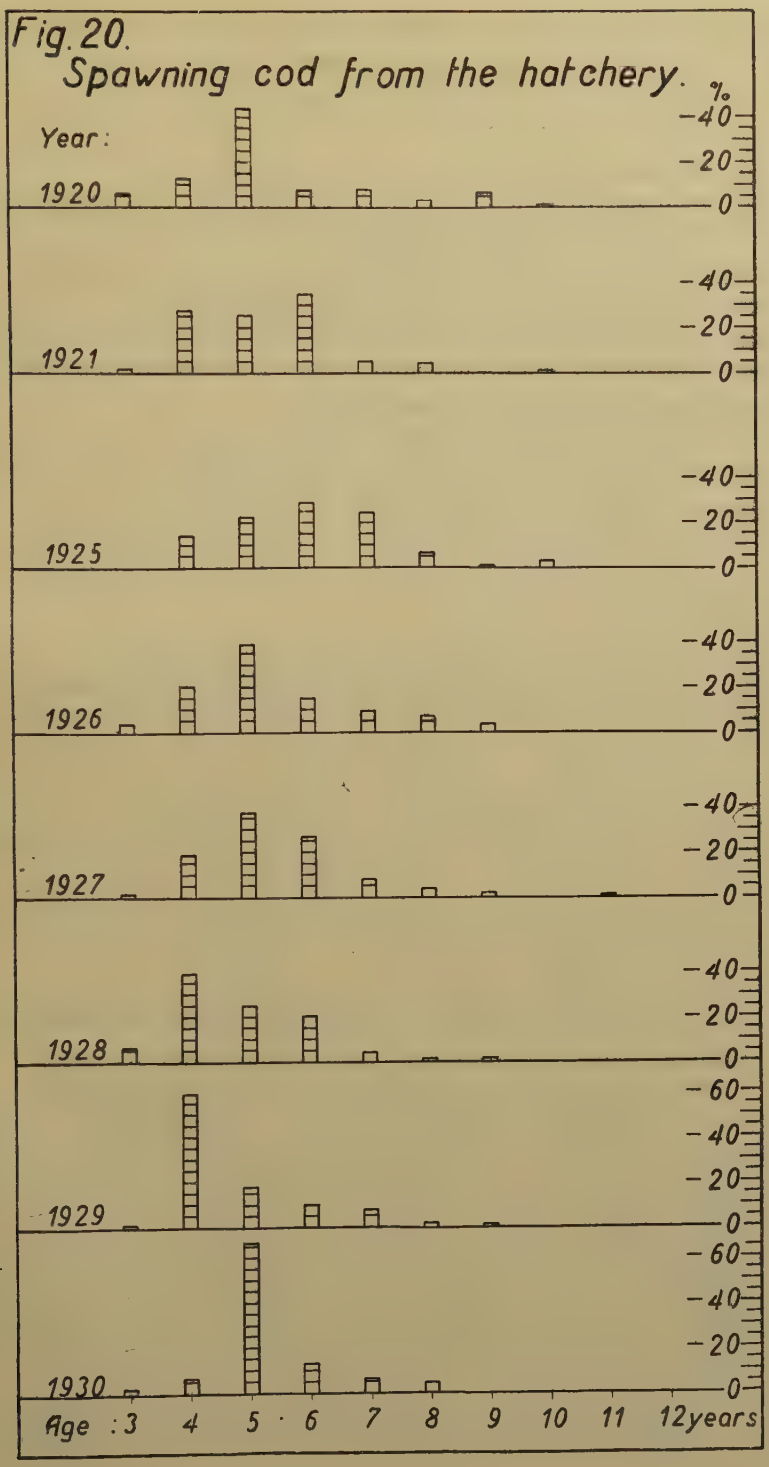
I have for a long time been of opinion that the cod in these waters are harvested at a very young age, but the figures now available show the position to be worse than I expected. It is of course open to question whether our method of fishing provides samples representative of the normal catch, no special investigations on that point having been made. From personal judgement I may say, however, that the traps which are commonly used along the coast catch fish mainly of intermediate sizes. The catches of the land seines used in spring consist of still smaller fish. On the other hand, the hook and line catches would probably give rather more of the larger sizes.

More representative samples for application to this special problem may be had by buying the fish at random in the market, and I hope means will be available for this purpose later on.

Passing to fig. 20 we have there measurements from market samples, but the individuals represented are only the largest obtainable. The results obtained verify the opinion arrived at by the other analyses. The spawning fish are generally very young, only 4—6 years of age, and here the method of selection is in favour of the largest (and oldest) specimens. It is furthermore evident that the intensity of fishing is very high in our waters.

Fig. 21 gives the mean size of the cod examined from the different localities. It is apparent that the cod from the Søndeledfjord are decidedly smaller than those from the other two places. (The data for cod 5 years of age and upwards are very scanty). This indicates that the cod in the Søndeledfjord, the most isolated of the areas considered, must be to some extent peculiar to that fjord.

Fig. 20.
Spawning cod from the hatchery.



During the period from 1903 to the present time a large number of cod in their first year has been collected from the fjords and skjærgård along this part of the coast. These data show that the size of the cod caught simultaneously in different places varies from fjord to fjord, and even from the mouth to the inner end of the fjord. This may be the result of different rates of growth, but may just as well be the result of a different spawning season in the different regions (vide Dannevig, 1930). As the material available is not sufficient to elucidate that problem these data will not be considered now.

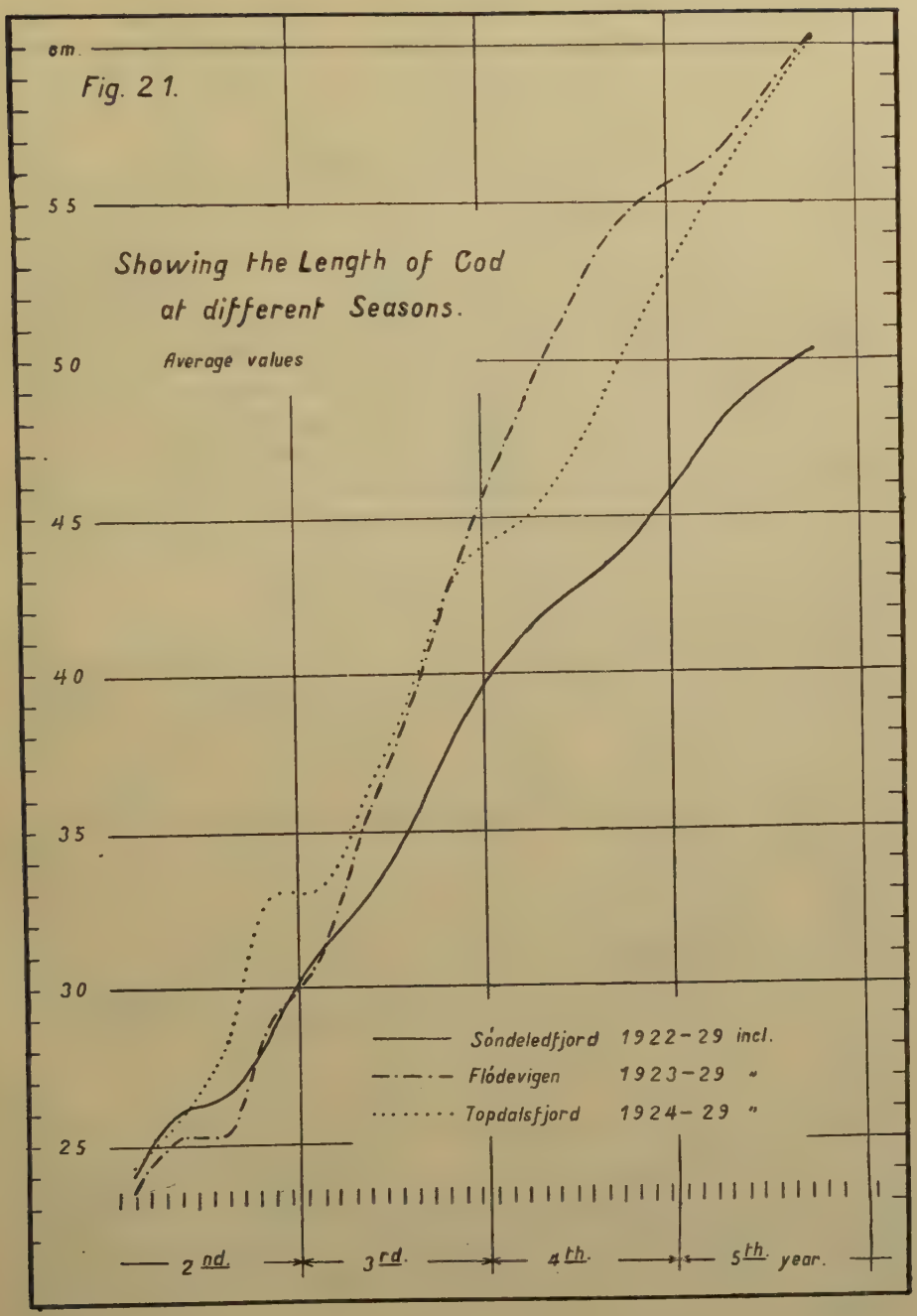
The detailed tables also show that the average lengths of the different year classes vary somewhat in the same fjord, but this point also will be omitted from the present paper.

In fig. 22 and table IX the age and length are given for cod caught by different methods in the waters near Flødevigen. As the otoliths were badly preserved, the scale method was used in this case. The mean length of the fish is less that that found by the otolith method, the scale method having apparently a tendency to put the fish into older year-classes.

Fig. 22 illustrates the importance of using fish caught by the same kind of gear when studying the relative strengths of the different broods. In 1914 the cod were caught chiefly by hook and line, in 1915 for the most part in seines near the shore, and in 1916 nearly all fish were taken with the seine. The result is that in 1916 samples nearly all the fishes were only one year old. During the years 1920—1922 chiefly traps were used, but in 1921 the data include some yearlings which were caught in a fine-meshed seine. Consequently the graph concerned is not comparable with the others. We will now consider the results arrived at by earlier investigations as to the growth and the occurrence of the cod in the same waters.

In the years 1904—1906 K. Dahl (Dahl, K. and Dannevig, G. M. 1906) examined the cod from the Søndeledfjord and the waters off the coast. This earlier statement of the size of the cod caught in that fjord is in full agreement with our finding, namely, that the fish are generally from 20 to 40 cm in length, though there are differences with regard to the age as well as to the length of the fish of the different year-classes.

In my opinion thise differences may be ascribed to the different ways of reading the scales and otoliths. If the method in general use at that time was employed, the age would be somewhat higher than by the method now adopted. The first zone in the scale & otolith being reckoned as a winter-zone, i. e. put down as if the fish were one year of age — instead of at the age of half a year. In Dahl's table E. 4, the


cm.
Fig. 21.
55
Showing the Length of Cod
at different Seasons.
50
Average values
45
40
35
30
Søndeledfjord 1922-29 incl.
Flødevigen 1923-29 "
Topdalsfjord 1924-29 "
25
2nd.
3rd.
4th.
5th. year.

age of 138 cod from the Søndeledfjord ($^{25}/_{11}$ 1905) is given, the age being computed from scales and otoliths. The average length found by Dahl's tables for cod about $2^{3}/_{4}$ years old agrees with the length found by us for cod $1^{3}/_{4}$ years of age. More over our measurements of cod $2^{3}/_{4}$ years old give even larger values than Dahl's for cod of $3^{3}/_{4}$ years of age. The length difference between the two groups given by Dahl, 4·6 cm for one year, is so small that it suggests that the method used was not quite reliable. From Dahl's marking experiments (Dahl and Dannevig 1906) it may be seen that the average increment of the cod recaptured more than one month after liberation, varied from ca. 6 to 13 mm a month. An average increment of ca. 8 mm a month would give values in concordance with the results arrived at by us.

In chapter V of "Fishing Experiments in Norwegian Fjords" by J. Hjort and K. Dahl (1900) Wollebæk gives the age of the cod in the Oslofjord estimated from measurements after Petersen's method. The cod collected from 19th September 1899 till 20th January 1900 give maximum values for the 0 group of approximately 16 cm and for the 1 group 41 cm, the average for the approximately 1 $^{3}/_{4}$ years old fish being 31·0 cm. For the south-western part of Norway Hjort and Dahl (page 156) give measurements made in August which indicate the approximate length of the $1^{1}/_{2}$ years old cod to be 23·8 cm. Although the material relates to other waters, it strengthens the opinion reached by our examinations.

Tab. 3. Showing the average length of cod in cm. For details see table X, page 120.

Age Year	Hjort & Dahl 1900		Author	Dahl 1906	Author	Dahl 1906	Author
	S.W. coast	Oslofjord					
$1^{1}/_{2}$	23·8	—	—	—	—	—	—
$1^{3}/_{4}$	—	31·0	28·8	—	—	—	—
$2^{3}/_{4}$	—	—	—	28·6	38·5	—	—
$3^{3}/_{4}$	—	—	—	—	—	33·2	44·0

In his paper Dahl (1906) has arrived at the conclusion that cod of group I are very sparsely represented in the fjord, which is in direct contrast with our results. On page 84 in the paper mentioned he gives the following details regarding the age of cod caught in seine & trap.

The Søndeledfjord, Autumn 1905.

Group:	0	I	II	III	IV	V	VI
Number:	215	6	67	46	20	3	3

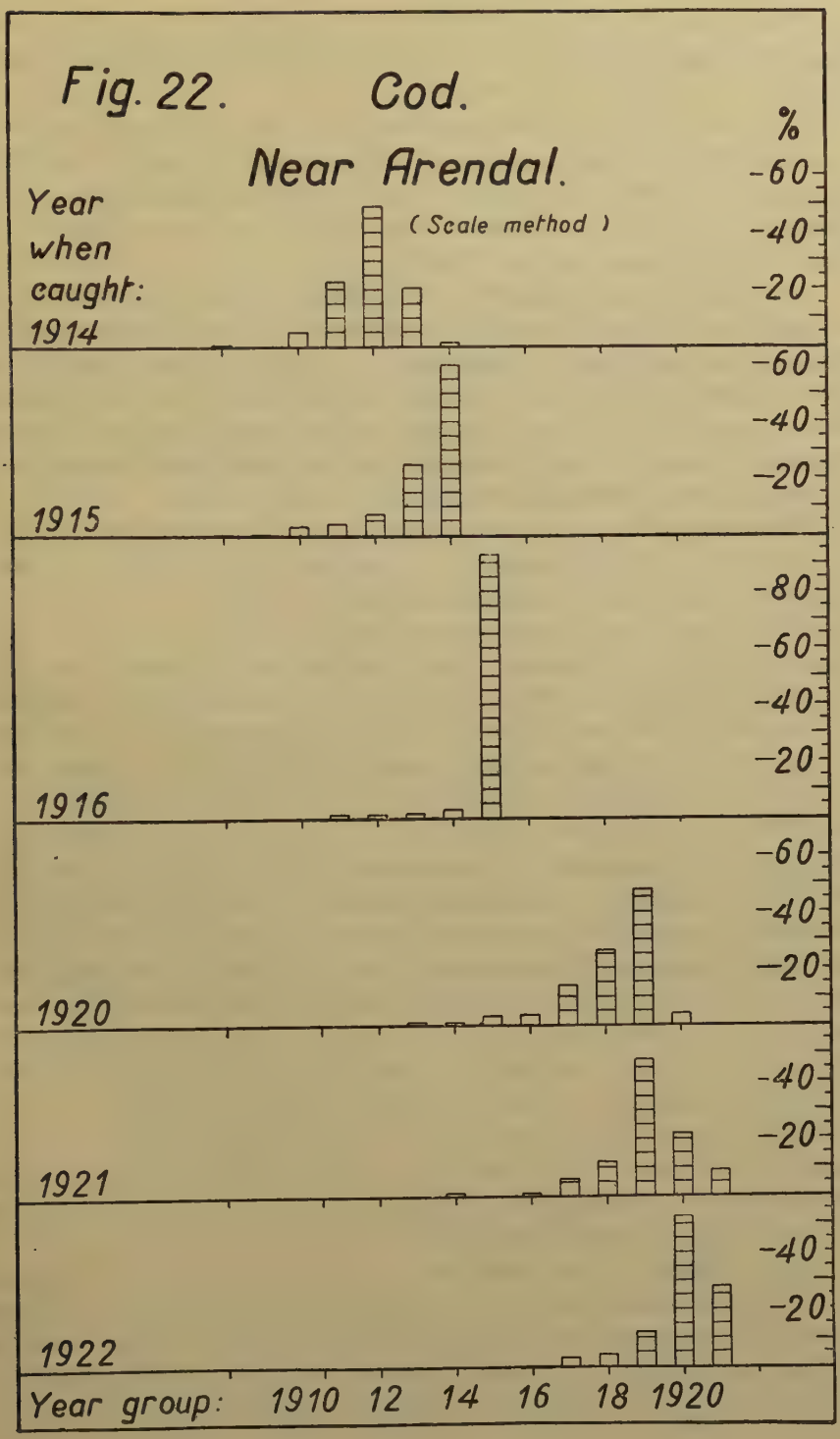


Fig. 22. Cod.
Near Arendal.
(Scale method)
%
Year when caught:
1914
1915
1916
1920
1921
1922
-60
-40
-20
-80
Year group: 1910 12 14 16 18 1920

From what has been previously said it may be reasonably assumed that this result is erroneous, the method of age-determination not being quite reliable at that time.

Professor Dahl is of the opinion that the Søndeledfjord is stocked each autumn by cod coming from the coastal waters outside the skjærgaard, and that the fish leave the fjord in the following spring. This opinion is based on the direct observations of the fishermen, the course of the fishery, and on marking experiments.

I do not think, however, that it is possible directly to observe the migration of the cod near the sea-bottom to a sufficient extent to furnish the basis for a theory on the ordinary migrations. The course of the fishery, moreover, may be caused by some difference in the time at which the cod concentrate in the shallow waters in the different regions. It may be that the cod concentrate earlier in the shallow waters near the coast than in the fjords.

With regard to the marking experiments, I have worked out table XI page 121 from information in professor Dahl's paper. Of 717 marked cod liberated, 97 were recaptured, i. e. 13.5 %. Of these 97 more than half the number was recaptured within one nautical mile from the place of liberation, only four individuals having been recaptured more than 5 miles away. One of these specimens migrated in the period between $^{1}/_{4}$ and $^{16}/_{8}$ from the Søndeledfjord (Nordfjord) to the skjærgaard, and another moved from outside the skjærgaard into the fjord between $^{4}/_{4}$ and $^{21}/_{10}$. The two others moved along the coast. One of the experiments, Håvik $^{17}/_{4}$, shows a general tendency for the cod to be recaptured on the seaward side of the place of liberation. In the other experiments no regular migrations can be discerned.

These facts, as far as they go, show that the great majority of the cod are recaptured close to the place of liberation and that while one individual liberated in the fjord may be captured in the skjærgaard, another may travel into the fjord from the coastal waters. If the conclusions from the marking experiment are limited to this interpretation, they are in full conformity with the results at which I have arrived, namely "— — that the cod in the Søndeledfjord, — — — must be to some extent peculiar to that fjord". Only by way of assuming local stocks in the different fjords we can account for the different rates of growth found.

The question of the occurrence of more or less local populations of cod in the fjords will, however, now be examined along the lines followed by professor Johs. Schmidt. It appears that the counting of the vertebrae gives interesting results (Schmidt, 1930). Although the material from our waters is very scanty, table 5 page 50 indicates

that the cod in the skjærgaard (Flødevigen) and the Topdalsfjord have fewer vertebrae than the cod off the coast. This is in agreement with the results obtained by Schmidt elsewhere.

Professor Dahl also notices the absence of fish more than 5 years old in the Søndeledfjord but leaves open the question of the reason of that phenomenon. He mentions the possibility that the grown cod may leave the fjord and are to be found on the banks off the coast.

My opinion is, however, that if the cod left for the banks in numbers great enough to account for their absence in the fjords, they would have been found by fishermen and brought to market. This is not the case, for old fish are caught in our coastal waters only very rarely. The age estimation of the fish which have spawned in the hatchery indicates that the full-grown cod are very rapidly decimated.

Damas (1909) gives, principally on the basis of the material collected by Dahl, the following figures for cod from the Søndeledfjord.

Age	Length
ca. 2 3/4 years old	28·7 cm.
- 3 3/4 — -	33·4 -
- 4 3/4 — -	37·2 -
- 5 3/4 — -	ca. 48 -

These results agree with those arrived at by Dahl but, as stated previously, they are very different from our results, and do not agree with the length increments of the cod marked by Dahl, nor with the analysis of the measurements of the cod in the Oslofjord. Furthermore, as will be shown later, his results differ very much from the values obtained with cod kept in captivity.

IV. The growth and the scale-structure of cod reared or kept in confinement.

From ancient times fresh-water fish have been kept in captivity, and many observations as to the rate of growth of the fish have been collected. In our days the fundamental experiments are those of Hoffbauer (1899) who succeeded in producing evidence that the zones in the scales of the carp were annual. Later a great deal of experimental work has been made in order to study the formation of zones in scales from fresh- and salt-water fish kept in aquaria, the age of the fish being known empirically. Fresh-water and some anadromous fishes have been reared from larvae, hatched from artifically impregnated eggs. In this way a great deal of information has been compiled in regard to the influence of external conditions on the rate of development, the growth of the fish and so on.

Owing to the difficulty of rearing the larvae of salt-water fish, especially those with pelagic eggs, the material in this instance is very scanty. The first successful experiment was made by G. M. Dannevig in 1886 (Dannevig 1887). He succeeded in rearing a number of the pelagic cod larvae hatched at Flødevigen, and in keeping some of them alive for two and a half years. In 1896 H. C. Dannevig succeded in rearing plaice larvae (Dannevig 1897) and in 1905 Fabre-Domergue gave the results obtained with the sole *(Solea vulgaris)*.

Of great interest are the experiments of Fulton (1904). He kept several fishes in tanks at Aberdeen, of which some were heated through the winter. During the years 1923—1926 Harold Thompson (1926) also kept several gadidae, mainly haddock, in tanks at Aberdeen, without controlling the temperature.

As the problem dealt with in this paper is the growth of the cod, we must limit our considerations to the gadidae, especially the cod.

A. Cod reared from larvae in the pond at Flødevigen.

Particulars of the pond in which the rearing experiments were performed will be found in my paper: "On the Growth of the Cod and the Formation of Annual Zones in the Scales. Experiments at the Flødevig Sea-Fish Hatchery" 1925.

The first experiment by G. M. Dannevig in 1886, provided the following data:

	Date	Age	Average length in mm.
Hatched	April 26.	0 days	about 3
Liberated in the pond:	May 3.	6 —	— 5
—	— 16.	19 —	— 7
—	— 18.	21 —	— 8
—	— 21.	24 —	— 9
—	— 31.	1 month 5 —	— 10
—	June 3.	1 — 8 —	— 12
		(50 individuals)	(9–16)
—	— 6.	1 month 11 days	about 15
—	July 12.	2 — 15 —	— 55
—	Aug. 12.	3 — 15 —	— 70
—	Sept. 12.	4 — 15 —	— 85
—	Oct. 12	5 — 15 —	— 115
			(max.) 157

My earlier experiments with rearing of cod larvae were started in order to study the biology of the postlarval stages; the measurements are, however, of interest in one case. The eggs were hatched about the 23rd of May 1909 and the larvae liberated in the pond on the 25th of May.

The average length of the larvae were:

May 25. Approximately ..... 3.5 mm
June 12. 2 individuals measured ..... 20.5 —
— 16. 2 — — ..... 27.5 —
— 18. 8 — — ..... 24.5 —

In 1930 I made an experiment in the pond in order to study the growth of the young cod and the formation of the first zone in the scales.

The pond was then supplied with water from the sea by a centrifugal pump delivering approximately 60 000 L. pr. hour. During the cod hatching season approximately 30 000 L. passes through the

pond every hour. Just before the liberation of the larvae, however, the water supply is stopped and the outlet closed, and during summer the pump is only worked occasionally.

It happens that pelagic fish eggs, and even larvae, are brought up by the pump from the sea. In some years I have observed young sprat, herring and a few mackerel in the pond. *Labrus rupestris* and *Gobius niger* often occur. Only in one instance, however, have I observed a *gadida*, a specimen of *Gadus merlangus* which had passed through the pump alive. But, of course, as the sea-water is not filtered it may be possible that an occasional individual of the cod reared in the pond has come in from the sea.

The particulars of this experiment are the following. On the 30th of April some cod larvae 6 days of age were liberated in the pond. From the 3rd of July, when the young fish had grown large enough, they were fed with the chopped-up soft parts of *Mytilus edulis*. Till then they had fed upon the plankton in the pond.

Table 4. Length of cod in the pond.
Hatched $^{24}/_{4}$. Liberated in the pond $^{30}/_{4}$ 1930.

Date when measured	28/6	13/8	11/10	13/10	29/11	11/12
cm	About 100 young cod approximately 1·5—2·5 cm in length were seen in one part of the pond	18 fish 3·5—7·5 cm				
5	—	—	3	1	—	—
6	—	—	6	3	6	—
7	—	—	2	9	4	—
8	—	—	3	5	4	1
9	—	—	1	4	8	2
10	—	—	—	6	7	3
11	—	—	—	2	1	5
12	—	—	—	—	4	1
13	—	—	—	—	4	5
14	—	—	—	—	1	2
15	—	—	—	—	2	1
16	—	—	—	—	—	1
17	—	—	—	—	—	—
18	—	—	—	—	1	—
Number measured		18	15	30	42	21
Average length, cm		4·8	6·5	8·1	9·8	11·8

On a few occasions some of the codlings were caught in a ring net, but as a rule the largest seemed to escape the net. The particulars are to be found in the accompanying table.

In the autumn the pond had to be emptied on account of a leakage and on the 29th of November 42 codlings were taken out for examination and 21 were kept alive and measured on the 11th of December, when they were once more liberated into the pond. The

Fig. 23. Scales of cod from the pond $^{29}/_{11}$, 1930.
No. 7. Length 77 mm.
- 41. — 113 „
- 42. — 175 „

variation in size and weight was very great: on the 29th of November the length varied from about 6 to 18 cm and the weight from less than 2 grams to more than 40 grams.

Table XII gives the estimated average width of the sclerites at different lengths of the fish. It will be seen that every individual had a zone with narrow sclerites at a distance equal to 3—6 cm of length of the fish, the smaller fish at a shorter length than the longer. Outside the narrow sclerites we find, especially in the bigger fish, a great many broad sclerites. The accompanying photographs illustrate this point (fig. 23).

The result obtained from this experiment is in full conformity with that which is found in fish naturally bred. Although the exact time of the formation of the zone cannot be stated, it will be evident from the measurements that it occurs approximately in the middle of August.

It is not possible at the present time to point to any particular cause for the great differences in length and weight. They may be a result of inherited qualities or of differences in the size of the eggs. The larvae in question orginated from the hatchery where the eggs are collected from several hundred spawning cod. The temperature of the pond will be seen from fig. 24 — it is generally a little higher than the temperature of the surface layers.

It may be of interest to note that the number of vertebrae found in this material varies considerably and is distinctly less than that found in cod living naturally in the waters.

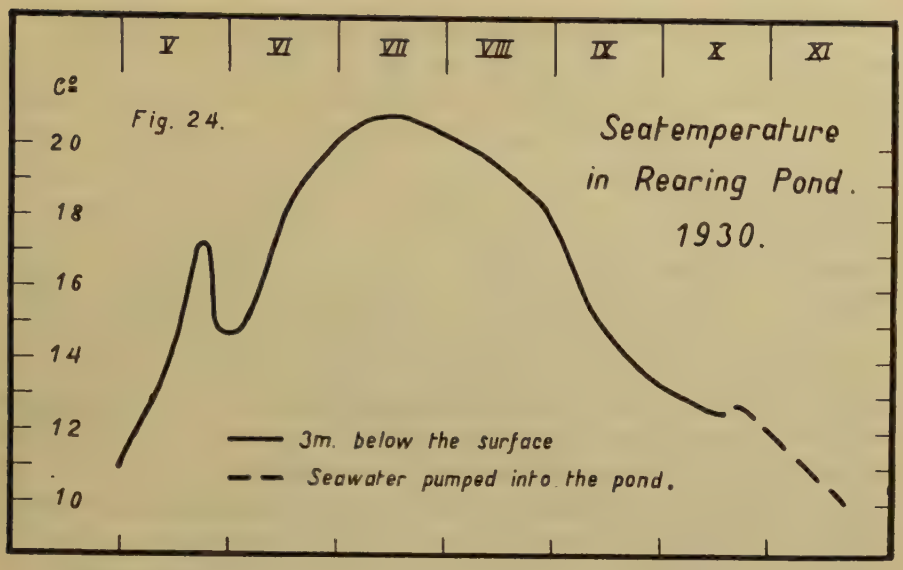
A few countings give the following figures:

Table 5.

Vertebrae	The pond 1930	Flødevigen 1915 & 1928	Spawning cod Arendal—Grimstad 1931	Topdalsfjord 1926 & 1927	Outside Arendal Schmidt,[1]) 1930. St. 66
44	1	—	—	—	—
45	—	—	—	—	—
46	—	—	—	—	—
47	1	—	—	—	—
48	4	—	1	—	—
49	11	2	3	—	—
50	16	41	48	4	—
51	7	137	107	26	6
52	—	65	19	7	10
53	—	5	2	2	6
54	—	—	—	—	2
Number examined:	40	250	180	39	24
Average no. of vertebrae:	49.48	51.12	50.81	51.19	51.17

Johs. Schmidt (1930) states that the number of vertebrae in the cod diminishes as we pass from the ocean into the fjord, and the figures now given show that the decrease continues as we pass from

[1]) As Schmidt counts the urostyle as a vertebrae, his figures are reduced by one in order to be comparable to ours.



the fjord to the pond. This exceedingly interesting problem will be studied later, when larger and better material is available. It looks as if the conditions in the hatchery or in the pond at that time were unfavourable to the formation of vertebrae — and, may be, also to the growth of some of the fish.

B. Cod kept in an aquarium.

Before dealing with my experiments in 1927—1930 on cod taken from the sea and kept in captivity I may refer to what had been done previously on these lines.

Fulton (1904) refers to some experiments with different species kept in tanks at the Marine Laboratory at Aberdeen. Of four tanks used, two were artificially heated during winter (the dates of the beginning or termination of the experiments are not given, however). The results obtained for cod and whiting are given in the following table, showing the increase in length (in mm) per 10 days. When the fish had survived 100 days they were measured and put back again. They were again measured after further 55 days. I have called the two periods a and b respectively.

Some haddock were also kept in the tanks, but did not thrive.

At the beginning of the experiment the length of the cod employed varied from 11 to 17 cm.

Table 6. Fulton rearing experiments showing the increase in length per 10 days in mm.

	Not heated				Heated			
Tank no	I		II		III		IV	
Experiment	a	b	a	b	a	b	a	b
Mean temp.	4·5	9·3	5·2	9·2	7·7	10·3	12·3	12·9
Whiting	1·6	2·52	1·77	2·55	2.13	2·49	2·74	2·85
Cod	3·65	6.87			3·29	7·05	4·63	9.76

It is evident that both the whiting and the cod grew faster with high temperatures than with lower. *But the extraordinary increase in the rate of growth of the cod in the heated tank no. IV from 4·63 mm per 10 days to 9·76 mm, when the temperature was raised from 12.3 to 12·9 degrees C. only, indicates that the temperature cannot be the sole cause actuating. Another factor — or factors — must have interfered.*

The fish were apparently fed abundantly, chiefly on mussels.

J. T. Cunningham (1905) deals with the scales & otoliths of some of the specimens from Fulton's tank experiments.

His observations on the otoliths examined in transmitted light may be summarised in the following way:

(1). Tank I. Cod 20·4 cm. Killed 4. Aug. 04.
Opaque central region — transparent zone — zone of opaque laminae.

(2). Tank I. Cod 24·8 cm. Killed 4. Aug. 04.
Opaque central region — transparent zone — zone of opaque laminae.

(3). Tank 4. (Heated) Cod 36·6 cm. Killed 5. Nov. 04.
Opaque central region — transparent zone — opaque zone — transparent zone.

The following points mentioned by the author are of interest:

(a) Zones are formed in the otolith of the cod from the heated tank where no seasonal variation of temperature has occurred.

(b) The specimen killed in November had a transparent zone near the margin which did not occur in the otoliths of the individuals killed in August.

The scales all show one winter zone. The actual age of the fish at the beginning of the experiments was not known, but they were probably in their first year (Cunningham).

Heincke (1905) gives the following data for cod kept in an aquarium at Helgoland: "Cod of the 0-group kept in our aquarium grow very quickly in the summer and autumn, especially with good feeding; e. g. from the beginning of August to the middle of September not less than 1 mm daily on an average, from the middle of September to the end of October still $^1/_2$ to $^1/_3$ mm daily; in the middle of November we had cod of the 0-group in our aquarium up to 15·5 cm. In the open sea, the growth would certainly be greater."

The following is an account of my own experiments in the pond at Flødevigen in 1919—22 (Dannevig, 1925).

150 of the medium size 0-group codlings caught in the sea at Flødevigen were put into the pond on 11th October 1919. From time

Table 7. Length of the cod.

Length cm	When liberated	When recaptured								
		1920					1921			1923
	11/10 1919	3/3	21/3	28/5	9–10/6	5/12	28/3	2/4	3–5/10	23/5
8	25	—	—	—	—	—	—	—	—	—
9	48	—	—	—	—	—	—	—	—	—
10	42	—	—	—	—	—	—	—	—	—
11	33	—	1	—	—	—	—	—	—	—
12	2	—	—	—	2	—	—	—	—	—
13	—	—	—	4	1	—	—	—	—	—
14	—	1	—	4	2	—	—	—	—	—
15	—	—	—	4	4	—	—	—	—	—
16	—	—	—	4	4	—	—	—	—	—
17	—	—	—	2	2	—	—	—	—	—
18	—	—	1	4	1	—	—	—	—	—
19	—	—	—	3	—	—	—	—	—	—
20	—	—	—	1	1	—	—	—	—	—
21	—	—	—	1	—	1	—	—	—	—
22	—	—	—	1	3	—	—	—	—	—
25	—	—	—	—	—	—	—	—	1	—
27	—	—	—	—	—	—	2	—	—	—
29	—	—	—	—	—	—	—	1	—	—
31	—	—	—	—	—	—	—	—	1	—
36	—	—	—	—	—	—	—	—	—	1
40	—	—	—	—	—	—	—	—	1	—
46	—	—	—	—	—	—	—	—	—	1
47	—	—	—	—	—	—	—	—	—	1
Total:	150	1	2	28	20	1	2	1	3	3
Average length	9·7 cm	14 cm	14·5 cm	16 cm	16·4 cm	21 cm	27 cm	29 cm	32 cm	43 cm

to time some of the fish were caught in the pond, some accidentally in the water pipes leading from the pond to the hatching apparatus.

The cod were fed twice a week with *Mytilus edulis* and *Cancer pagurus*, except during the winter months when the pond was covered with ice and the feeding discontinued.

The details of the measurements are available in text table 7.

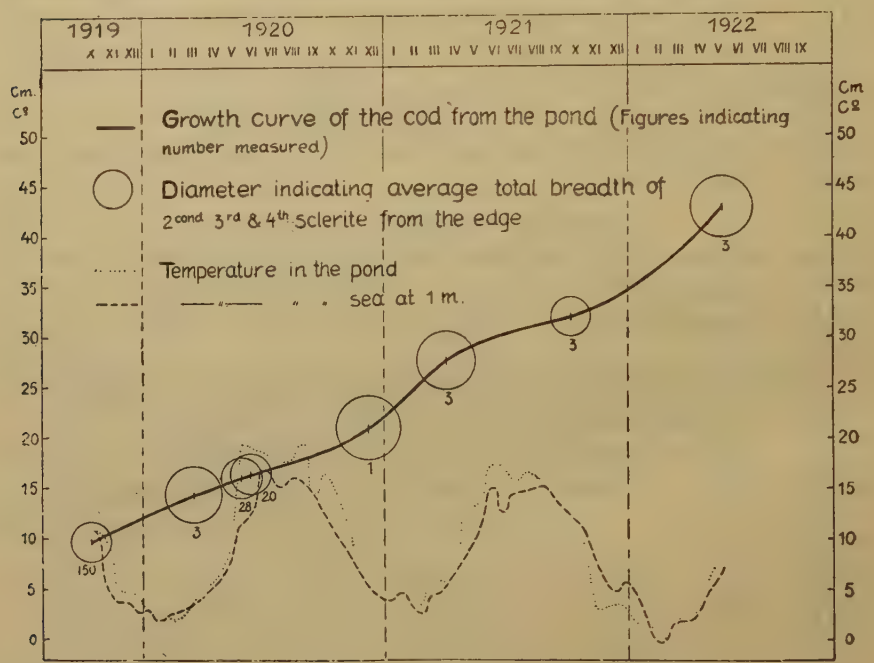


Fig. 25. Cod from nature kept in the rearing pond.

The average length of the fish and the average breadth of the sclerites near the margin are shown in fig. 25, together with the temperature in the pond and in the sea.

As already mentioned in the preface the results stood in direct contrast to the general opinion; the specimens caught during winter exhibited a greater length compared to those caught in autumn, indicating that the length increment during winter was great. Further the zones with narrow sclerites in the scales were ordinarily formed in late summer or early autumn, large sclerites in winter.

In 1926 Harold Thompson gave the result of his rearing experiments of some gadoid fishes, chiefly haddock, in tanks at the Nigg Aquarium, Aberdeen.

The tanks were supplied with water from a reservoir, into which it was pumped from the bay. Owing to the heating of the laboratory, the temperature in the tanks was 0·5—1° C higher than in the sea, the difference being more marked in winter. The actual temperatures in the sea or tanks are not given.

The fish for the experiments were taken from the sea, a few scales were secured and the specimens placed in the tanks. The parent shoals at sea were watched and the length increment so found used as a control of the rearing experiments. The fish were measured at intervals (approximately quarterly) and scales secured. As a number of fish were kept together in the same tank the averages were given, though in a few instances the growth figures refer to a single individual.

On the basis of the material available I have compiled the following table, giving the approximate length increment per 10 days of the cod examined.

One cod, 21·5 cm, placed in tank 15. June 23, showed the following increment:

Period.	Increment	Increment per 10 days
15. June, 23—31. Aug., 23	60 mm	7·9 mm
31. Aug., 23—15. March, 24	120 -	6·2 -
15. March, 24—20. May, 24	25 -	3·8 -
20. May, 24—29. Aug., 24	15 -	1·5 -

It will be seen that the growth-rate decreases rapidly and constantly; during the autumn and winter, from 31. Aug.—15. March it is four times as high as during the summer from 20. May—29. Aug. The rate of growth during the second summer is exceedingly slow.

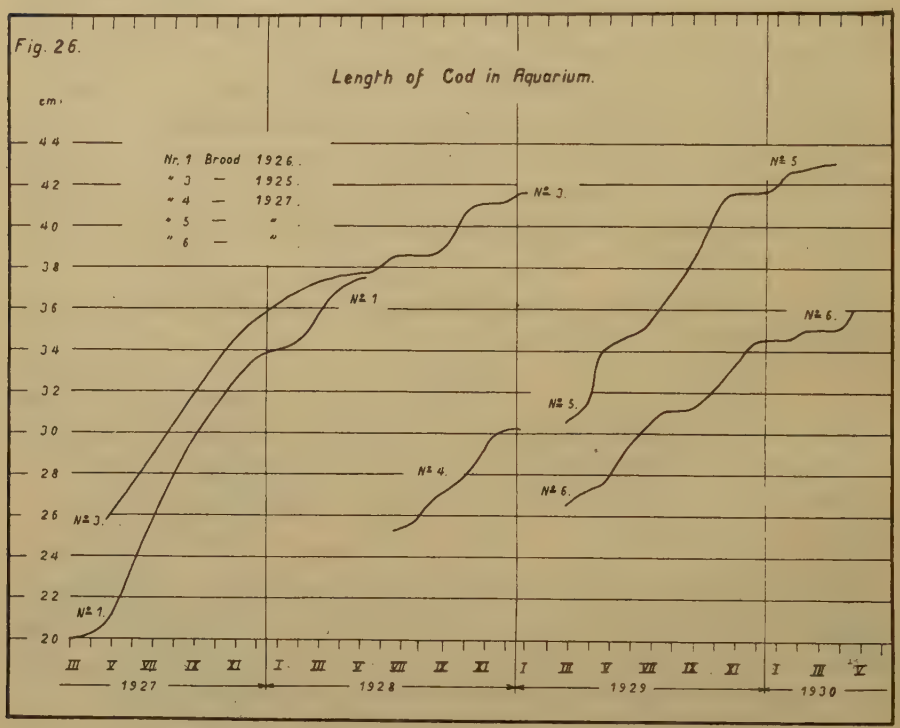
The average figures for four specimens are as follows:

Period	Increment	Increment per 10 days
16. Apr., 24—27. Aug., 24	70 mm	5·4 mm
27. Aug., 24—17. Oct., 24	22 -	4·4 -
17. Oct., 24—20 March, 25	78 -	5·1 -
20. March, 25.—30. June, 25	30 -	3·0 -

The average growth-rate is highest in the first period, at 5·4 mm per 10 days from the middle of April till the end of August, decreasing to 4.4 mm from the end of August till the middle of October, but rising once more to 5.1 from the middle of October till the 20th of March. From March till the end of June it reaches its lowest value, 3.0 mm.

The total increment is stated to be about one third more than that of the fish in the sea. It is, however, hardly possible to assess the growth of the cod in the sea by measuring the "parent shoal".

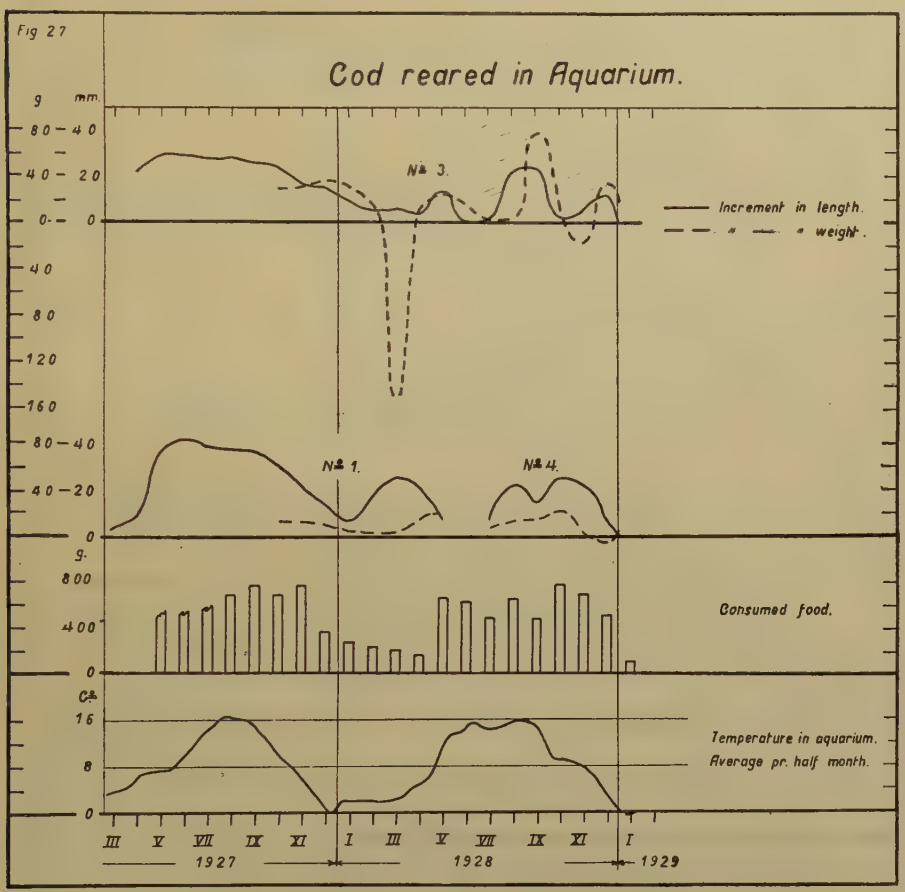
Thompson states that the size reached by the cod one year of age at the beginning of April was 10.5 cm just off Cruden; in deeper water of Aberdeen it was 15.5 cm. It will be understood that a slight



movement, or intermingling of the shoals may considerably affect the size found for the "parent shoal". Regarding the scales it is stated that the winter mark is generally found, but it is not distinct. In one case it was absent. From his illustration, Plate IV, figure 4, it is evident that "false" zones often occur.

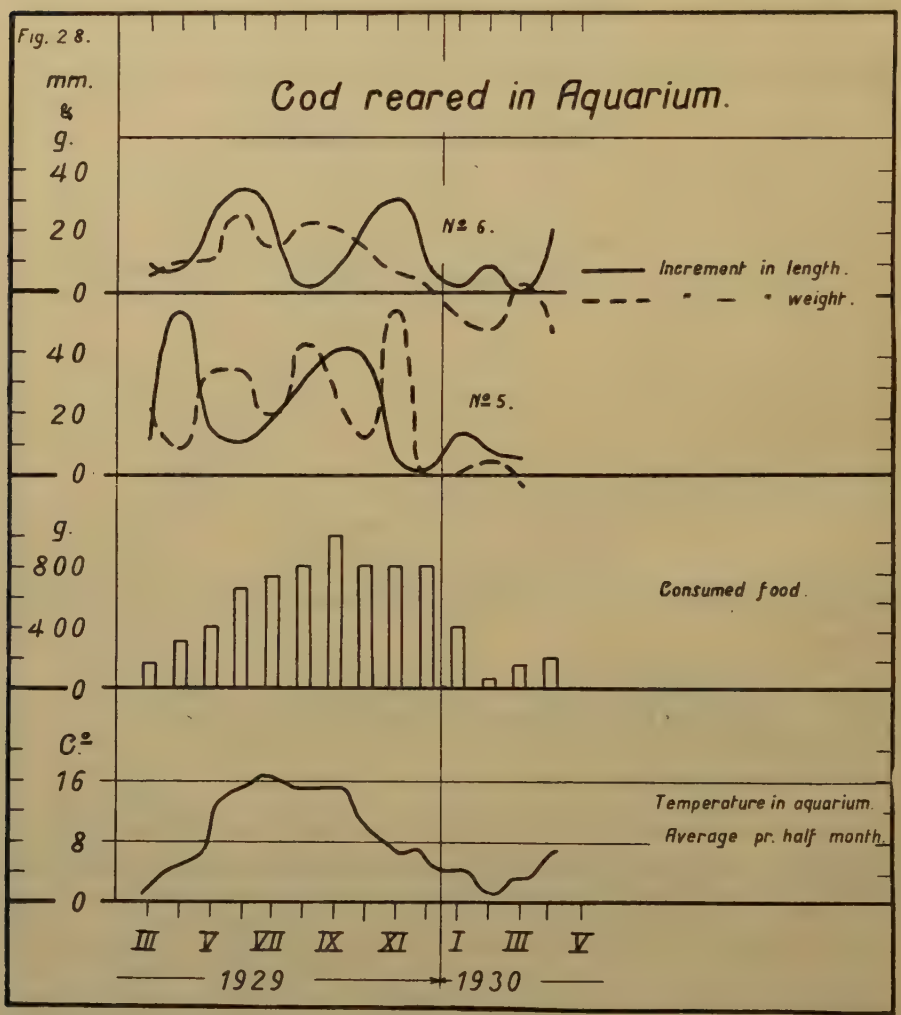
As to the growth of the haddock it appears that the "first year haddock" had a large length increment from September to December, and from the middle of May till June, when they died. Two batches of "2nd year haddock" both show a constant decrease in length increment from May 1924 till March 1926. "Third and fourth year haddock" show maximum growth in September, minimum in March. As a rule the scales showed winter rings, with a prominent pseudo-winter ring in addition, if the individuals were transplanted from the sea to the aquarium during the period of rapid growth (September).

Furthermore, in quick-growing individuals in the tank & in the sea a zone of slower growth is found in the middle of the growth period on the scale "indicating that there are often two spurts of growth in such fish, one occurring in spring, the other in autumn." The data given in the paper are not very detailed, so that a thorough discussion of the problem is scarcely possible.



As to the constantly decreasing length increments of the cod and 2nd year haddock, I am of the opinion that an unknown factor has had an important influence here. Perhaps the size of the tanks, 60—100 cubic feet, was too small, or the water supply not sufficient. It is stated that the oxygen content tended to fall during the warmer months. The fish were amply supplied with food, though the food consumed during winter was relatively sparse.

On the 14th of March 1927 I started some experiments in an aquarium at Flødevigen. The aquarium used is situated in the hatching room. Its dimensions are 160 × 97 cm, with a normal depth of water of 40 cm. The water is constantly renewed from the



pond previously referred to. Generally two cod were kept in the aquarium but they were of different sizes so that no mistake might occur. The fish were regularly supplied with food according to their appetite, but did not take any till the 3rd of May. From July 20th the food was weighed, and what was left the next day was taken out of the tank and weighed again. At intervals, from 1 to 2 months,

the fish were weighed and measured, and a few scales removed from below the second dorsal. When it happened that one fish did not thrive it was discarded for experimental purposes, and a fresh one secured, a healthy condition of the fish being fundamental for such experiments.

The length of the fish at different seasons and their age (found from the scales and otoliths) are given in fig. 26, a few short-lived specimens being omitted.

It will be seen that the length of the cod at the beginning of the experiment varied between 20 and 30 cm, and the age between one and two years.

Figs. 27 & 28 show the increment in length and weight per month, the food consumed (the cod were fed with the soft parts of *Mytilus edulis)* and the temperature of the sea water in the aquarium.

The following points are to be observed:

a. The consumption of food stands in close relation to the temperature of the sea water. In winter the consumption is less than 100 grams per month per 2 individuals (only 2 individuals were kept in the aquarium at the same time).
b. The increment in length is periodic, and always very small for a short time in winter; slow growth also occurs during summer. Rapid growth takes place in spring, summer and autumn, but does not occur at the same time in all specimens. No simple correlation between length increment and temperature is apparent.
c. The increment in weight varies considerably. This may in part be due to the relative fullness of the stomach. The great decrease in weight for no. 3 in March 1928 was caused by spawning.

When studying the sclerites of the scales from cod kept in captivity as a rule 3—5 scales were measured, and the average values entered in the tables. This was done in order to smooth the curves. In the tables I have also given the averages for all observations, which will give the main variations, but by so doing we run the risk of losing essential features.

To illustrate the variations of sclerites I have drawn the sclerite curves (fig. 30) from 5 scales from cod no. 1 in the aquarium. It will be seen that the curves of the single scale are difficult to decipher. In fig. 29 and 31 the averages are given for the last sample taken, and also the averages for all measurements of the fish. As may be expected the curve for the last sample only, gives more details than the curve for all samples.

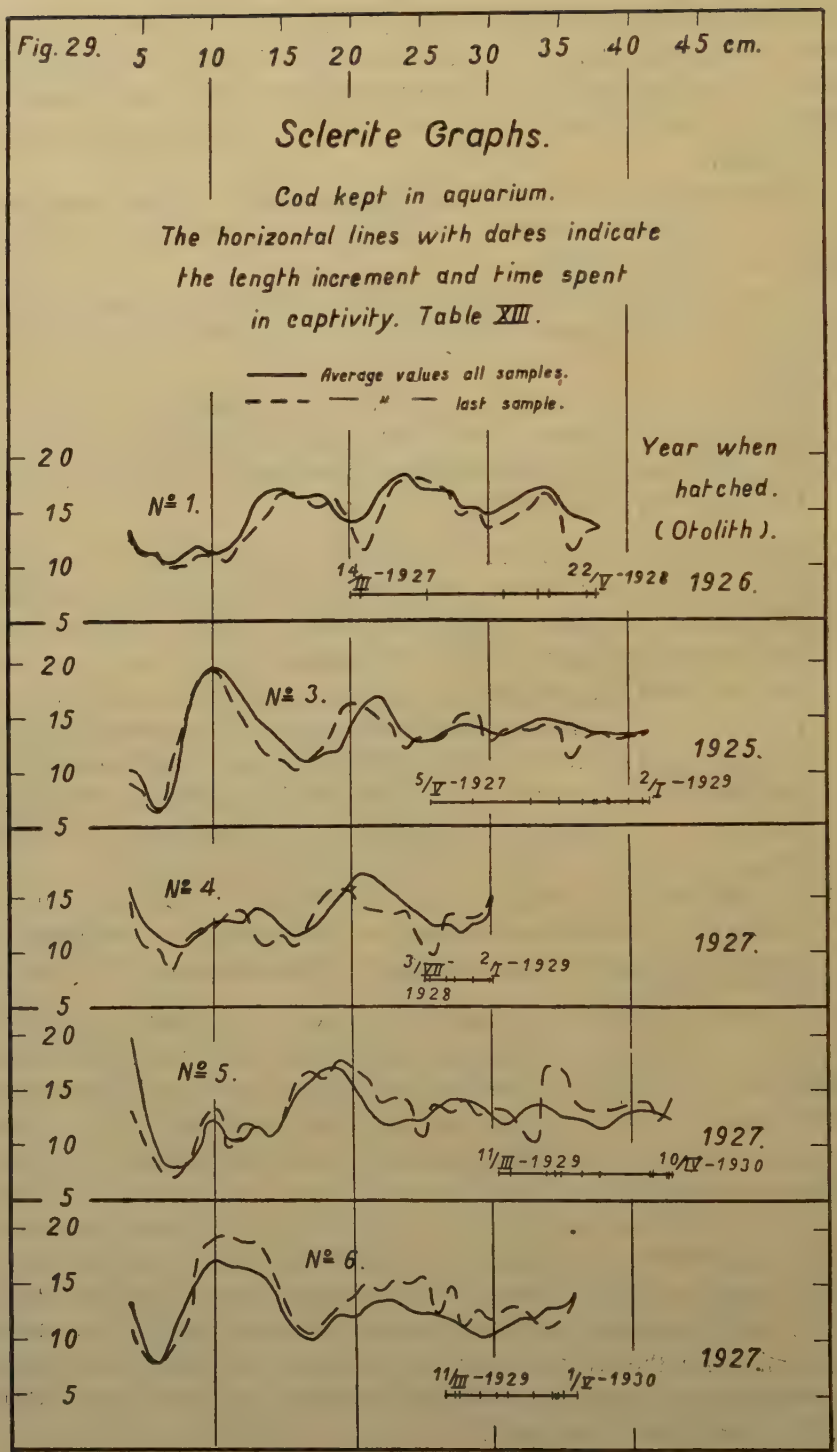


Fig. 29.
5 10 15 20 25 30 35 40 45 cm.
Sclerite Graphs.
Cod kept in aquarium.
The horizontal lines with dates indicate
the length increment and time spent
in captivity. Table XIII.
Average values all samples.
" last sample.
Year when hatched. (Otolith).
№ 1.
14/III-1927
22/V-1928
1926.
№ 3.
5/V-1927
2/I-1929
1925.
№ 4.
3/VIII-1928
2/I-1929
1927.
№ 5.
11/III-1929
10/IV-1930
1927.
№ 6.
11/III-1929
1/V-1930
1927.

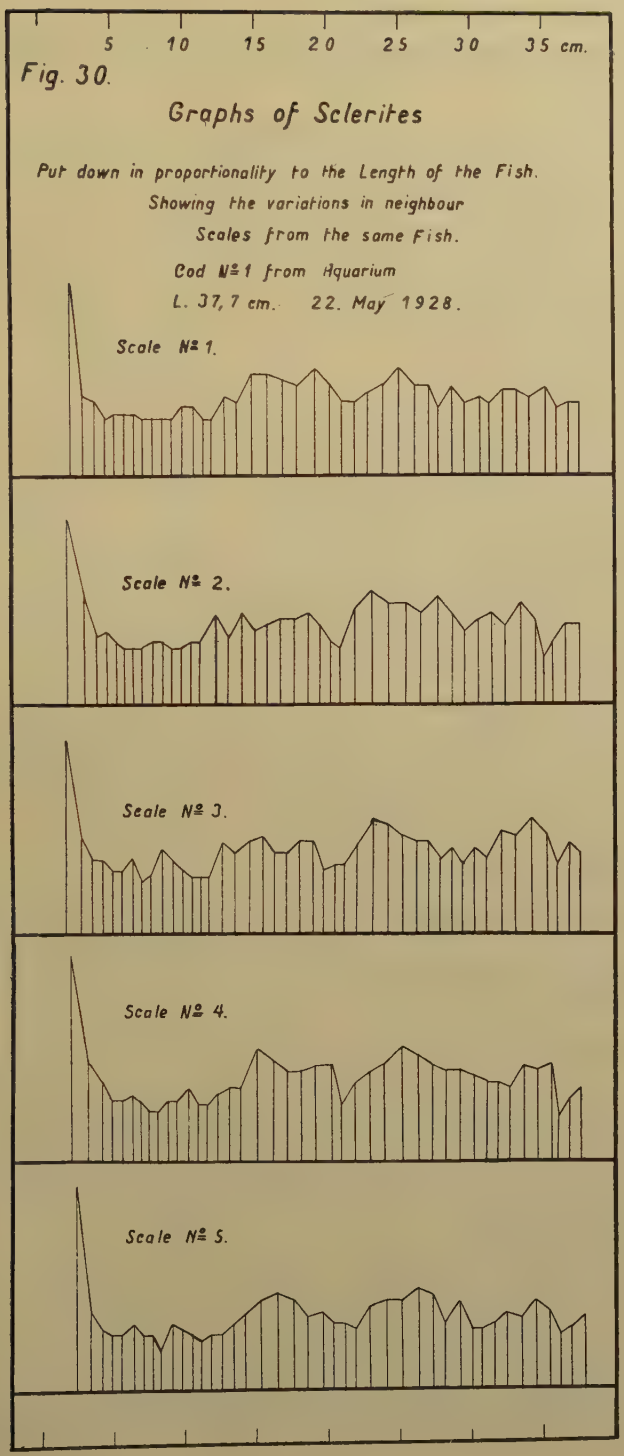


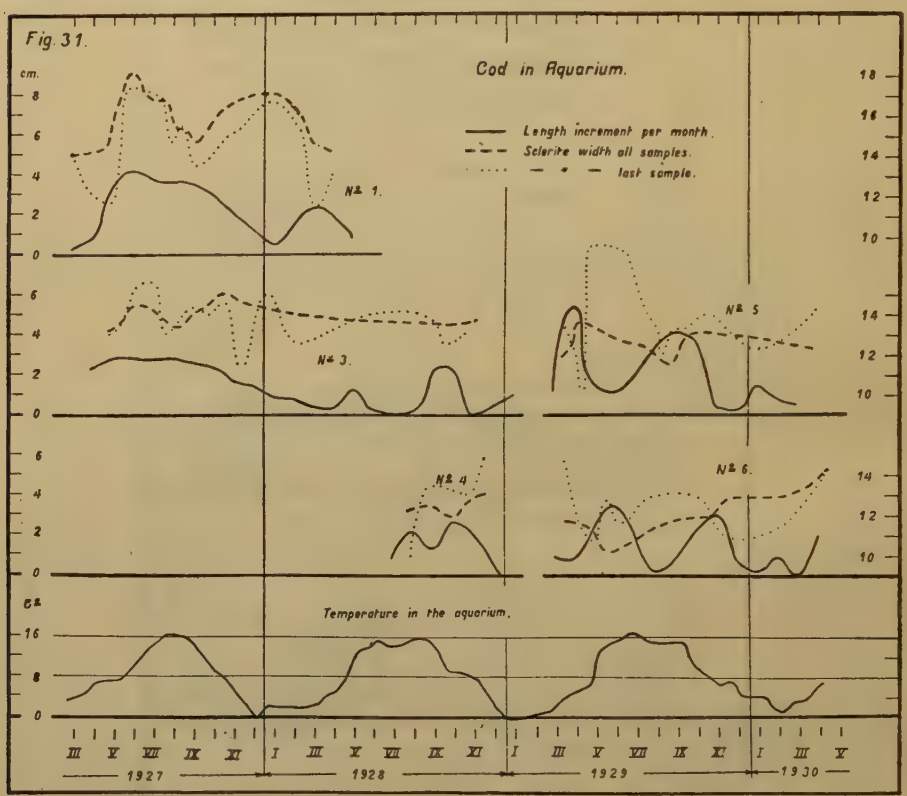
Fig. 30.

Graphs of Sclerites

Put down in proportionality to the Length of the Fish.
Showing the variations in neighbour
Scales from the same Fish.
Cod Nº 1 from Aquarium
L. 37,7 cm. 22. May 1928.

It is, however, very difficult to compute the age of the individuals from the curves. The scale itself is better, but far less clear than the otolith.

On studying table XIII, it becomes evident that the computed length of the fish, when the sclerite width is at a minimum (forming



zones) varies from observation to observation. This may be caused by the scale samples not being taken exactly from the same place. This is naturally not possible with living fish from which several samples have to be taken. Besides some variations may arise through the periodicity of growth in the fish, as this may not be quite proportional to the growth of the scale.

Fig. 29 illustrates the size of the sclerites computed for each length of the fish (according to table XIII) and the length when the fish was put into the aquarium and whenever samples were taken.

Fig. 31 gives the length increment in captivity and the computed sclerite width. The following conclusion may be drawn: *There is no proportionality between the length increment of the fish and the size*

of the sclerites. Maximum sclerites may occur when the growth increment is very small, and minimum sclerites when the increment is large.

Cod no. 1 had small sclerites in April, September and March; no. 3 in May, August, November and March; no. 5 in April, August and January; no. 6 in April—May and November—January.

It seems that the ordinary time for the formation of minimum sclerites is in March—April and in August—September. There is no correlation apparent between the size of sclerites and the temperature.

C. Cod kept in confinement in the sea.

A wooden box of dimensions 2·34 × 1·15 × 0·90 m was used for these experiments, and was kept floating nearly submerged in the sea. In order not to injure the fish the top was not permitted to sink under the water surface, as otherwise the dorsal fins will often be hurt.

It was constructed from boards and amply supplied with holes for the circulation of the water. The bottom, however, was solid in order not to let out the food. We tried in this experiment also to remove the food not consumed during the night, but owing to the difficulty in finding it I cannot trust the figures attained in this way. As in the aquarium the fish were plentifully fed with shelled *Mytilus*.

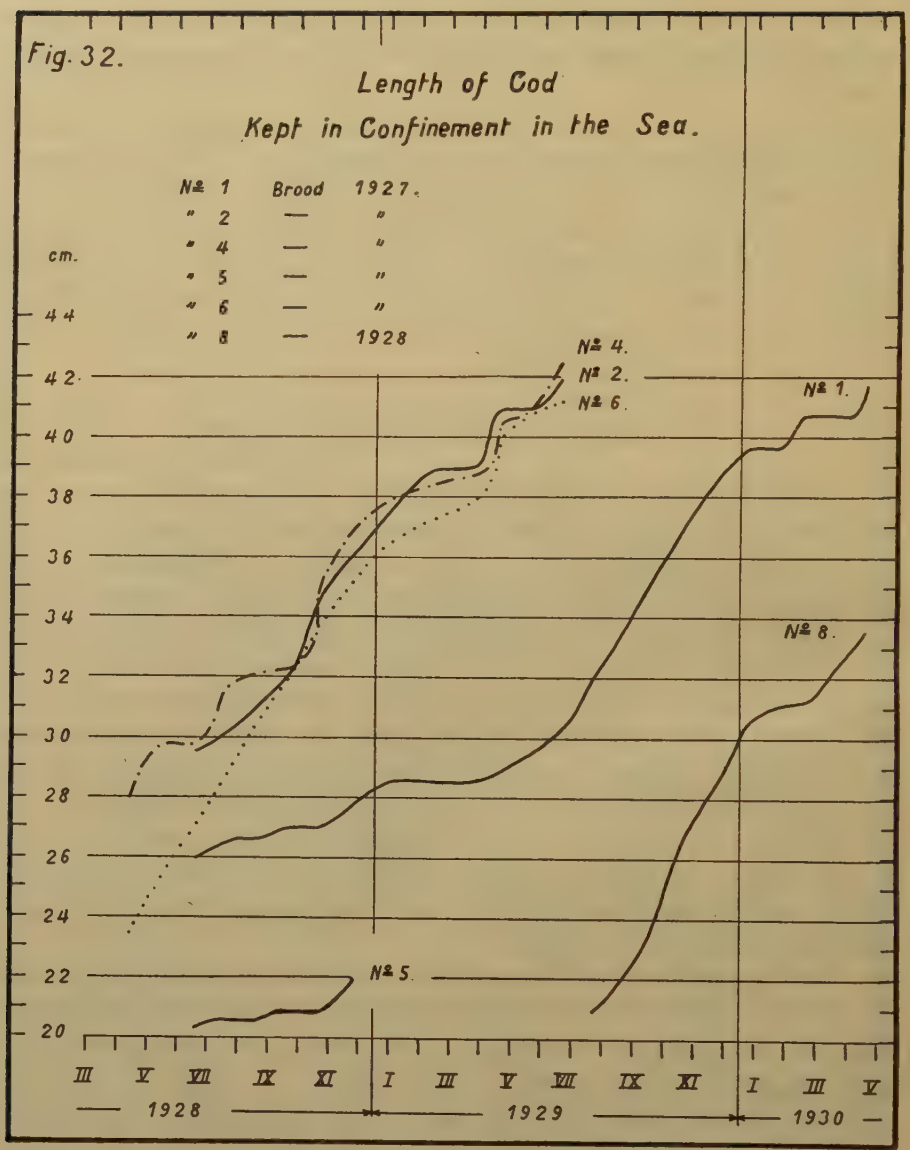
The box was divided into 3 compartments, each containing one or two fishes. In order to avoid injuring the fish no marks were used. When two fish were placed in the same compartment they were identified by their different lengths.

The age and size of the cod, and the duration of the experiments are given in fig. 32. Fish between 20 and 30 cm in length (at the beginning of the experiment) were used; their age was a little more than one year.

The sclerite curves of the whole scale in relation to the length of the fish are given in fig. 33.

In fig. 34 we find the curves showing the length increment per month and the corresponding sclerite values (units on the right).

The length increment is in all cases very small in February—March, when the temperature is at its lowest. Very slow growth also occurs at other seasons, even in the middle of summer. The sclerite curves show no correlation with the curves of length increment. Minimum sclerites as a rule occur in August—October. The winter minima are not conspicuous.



A further discussion of the scale material from cod kept in confinement has to be postponed till more experiments have been performed; especially with cod kept under constant temperatures, with varying food etc.

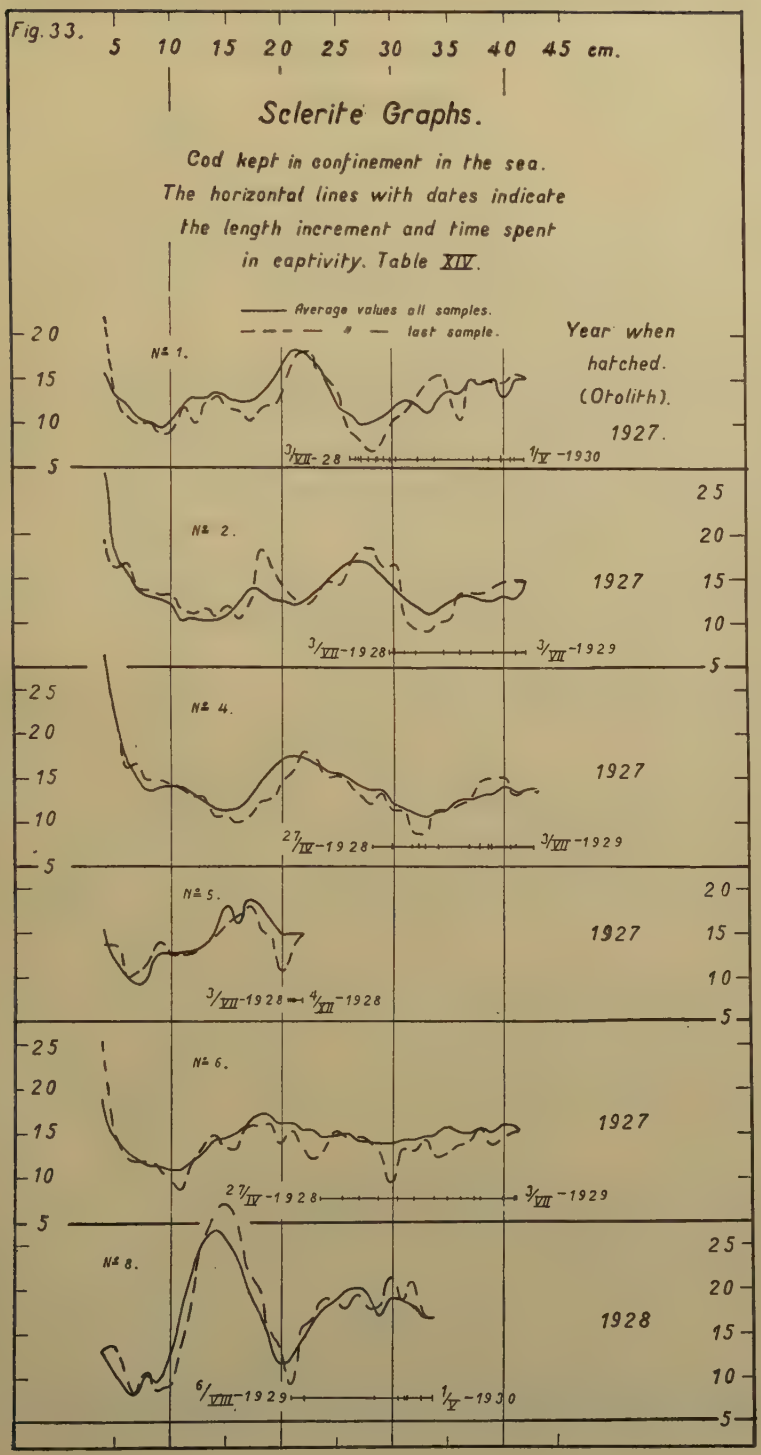


Fig. 33.
5 10 15 20 25 30 35 40 45 cm.
Sclerite Graphs.
Cod kept in confinement in the sea.
The horizontal lines with dates indicate
the length increment and time spent
in captivity. Table XIV.
Average values all samples.
" — last sample.
Year when hatched. (Otolith).
№ 1.
3/VII-28
1/V -1930
1927.
№ 2.
3/VII-1928
3/VII-1929
1927
№ 4.
27/IV-1928
3/VII-1929
1927
№ 5.
3/VII-1928
4/XII-1928
1927
№ 6.
27/IV-1928
3/VII-1929
1927
№ 8.
6/VIII-1929
1/V -1930
1928

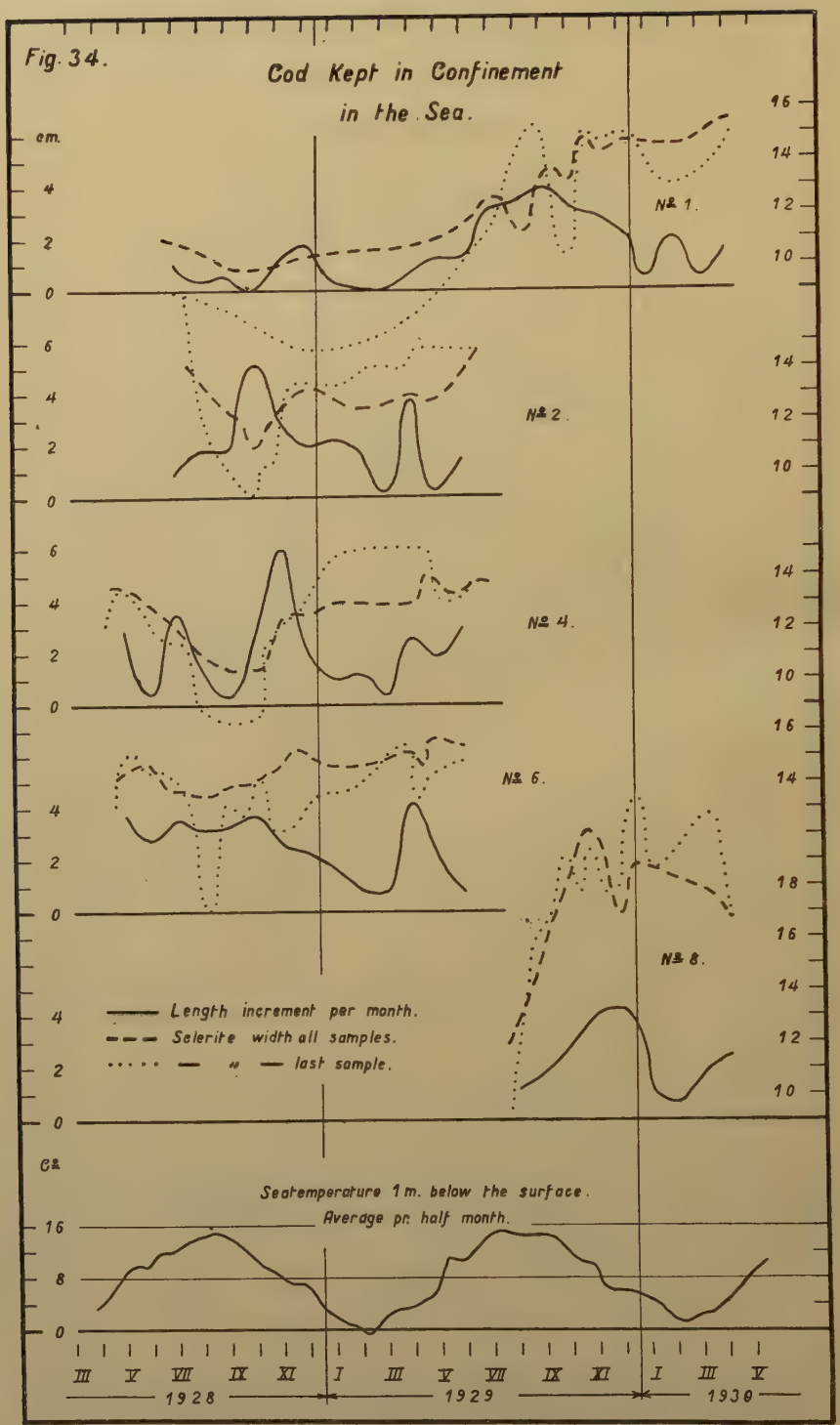


Fig. 34.
Cod Kept in Confinement in the Sea.
cm.
№ 1.
№ 2.
№ 4.
№ 6.
№ 8.
Length increment per month.
Selerite width all samples.
" " last sample.
C°
Seatemperature 1 m. below the surface.
Average pr. half month.
III V VII IX XI I III V VII IX XI I III V
1928
1929
1930

V. Summary.

The chief purposes in starting these investigations were to find the best method for determining the age of cod from the Norwegian Skagerrack coast, and to estimate the age-composition of the stock and the growth of the cod in these waters. As the investigation of the method brought to light the fact that the ordinary scale theory, the formation of narrow sclerites during the hydrographical winter, did not hold good in these waters, it became desirable to obtain data for an inquiry into the factors involved in the growth of the individual fish and its scales, and the production of the zones in the scales and otoliths.

In order to study the method for age determination, material was collected from the Søndeledfjord near Risør, the Topdalsfjord near Kristiansand and the skjærgård at Flødevigen. There were no means available of obtaining sufficient material from the Skagerrack off the coast. The material was always collected with the same sort of fishing gear, samples were taken every month of the year during the period 1922—1929 inclusive, from the Søndeledfjord and Flødevigen, and during 1924—1929 from the Topdalsfjord.

Measurements of the sclerites in the scales show that minimum sclerites as a rule occured first when the fish had a computed length of 5—8 cm, which the fish normally reach during the month of August. The minimum sclerites are soon followed by large sclerites; maximum values are found when the fish reach a length of about 11 to 20 cm.

Measuring the sclerites near the margin of the scale made it evident that the values varied from month to month. As the last sclerite, however, may not have completed its growth, the breadth of the sclerite lying at a distance from the margin proportional to 1 cm of the growth of fishes was used.

The values are shown graphically in fig. 7, page 18.

The curves for the different fjords and years vary, but we notice the following points regarding cod of less than 40 cm (immature cod).

1. During the period August—October all curves show one distinct minimum.
2. Minima occur in other seasons also.
3. All curves, except that for Søndeledfjord in 1928, show high average values during late autumn or early winter.
4. High values are also found in summer.

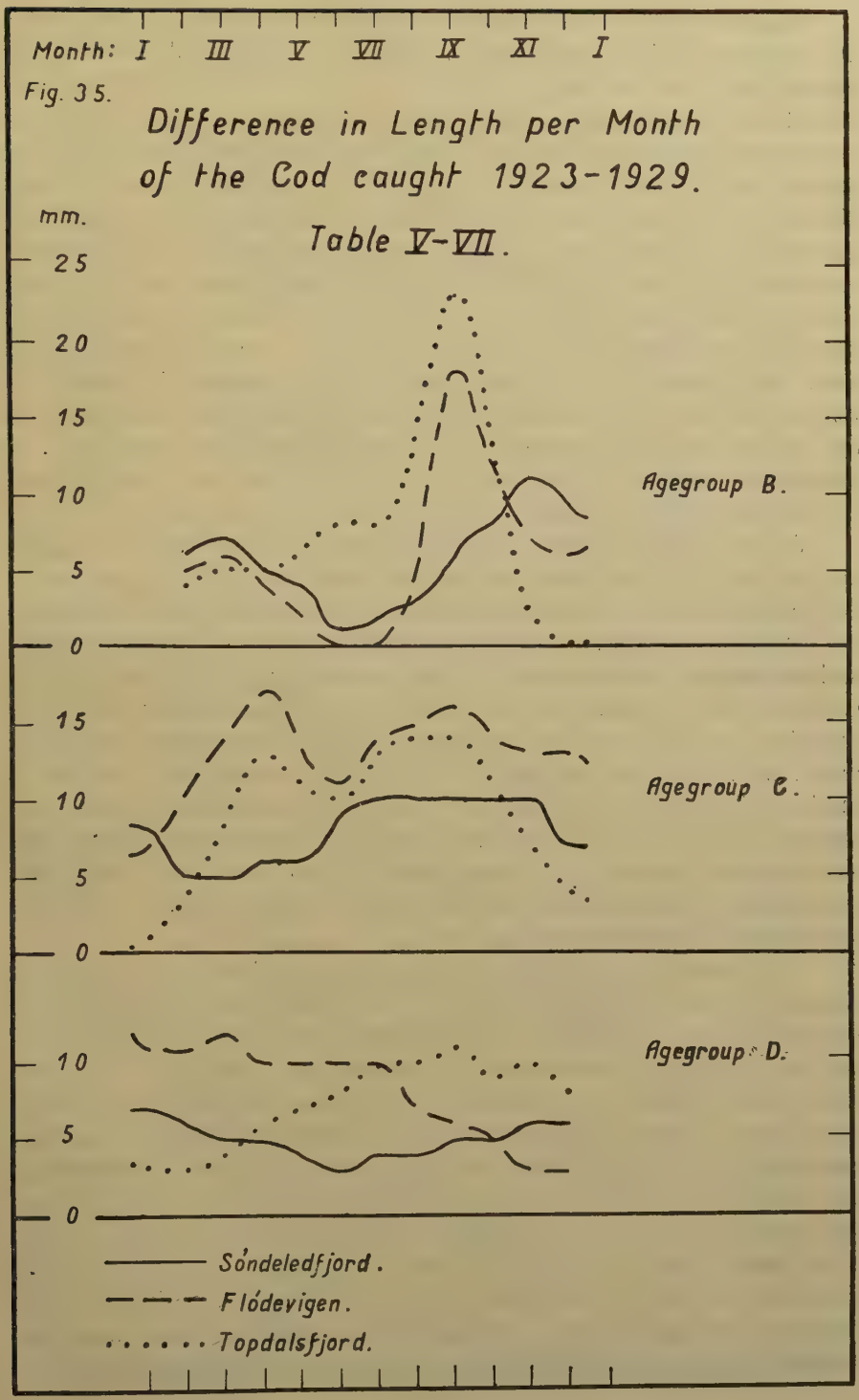
The sclerite measurements of the larger fish (more than 40 cm in length) show great variations. Three of the four curves, however, show distinct minima in February, September and October, (Fig. 8 page 20).

It must be remembered, however, that the curves show the breadth of the sclerites at a distance from the margin of the scale corresponding to one cm of the growth of the fish. A minimum shown for October is thus in fact formed somewhat previously, approximately one month earlier.

The values here referred to are averages. The material has, however, also been studied individually, and for each month is given the number of fish having narrow or wide sclerites at the margin of the scales. The results are summarised in fig. 9, page 22. Scales with narrow sclerites at the margin are found in all months of the year, but it is evident that August is the principal time for the formation of the narrow zones. Broad sclerites predominate at the margin from November to July. As the great majority of the scales (in one case 100 %) have narrow sclerites at the margin in early autumn it is reasonable to assume that the zones found at other seasons are supernumerary. As it is impossible to distinguish between the zones formed in the different seasons, some errors must be expected when using the zones in the scales for age determination.

The study of the otoliths, however, revealed the fact that the transparent zone here occured at the margin only in summer and autumn, at times to an extent of 100 %. Opaque zones at the margin predominated (occasionally 100 %) from November to May. The occurrence of the zones in the otoliths is thus much more regular, and as they are easily distinguished they are to be preferred for age estimations *(Vide* plate I—IV.)

Having due regard to the facts that the zones are formed as a rule in early autumn, and that supernumerary zones sometimes occur, the results obtained in computing the age of the normal catches from the scales did not differ much from the results obtained by the otolith method. With older fish, however, the difference was great. Of a total of 1565 cod from the Topdalsfjord the percentage of divergences between scale and otolith readings varied from 0·7 % in the youngest to 66·7 % in the oldest fish. The average was 8·8 %.


Month: I III V VII IX XI I
Fig. 35.
Difference in Length per Month of the Cod caught 1923-1929.
Table V-VII.
mm.
25
20
15
10
5
0
Agegroup B.
15
10
5
0
Agegroup C.
10
5
0
Agegroup D.
Søndeledfjord.
Flødevigen.
Topdalsfjord.

Regarding the age-composition, the analyses show that the young fish predominated in the catches. In the Topdalsfjord about 70 % and in the Søndeledfjord nearly 75 % of the cod caught were less than three years of age. Similarly the analyses of the spawning cod at Flødevigen show that the younger spawners are overwhelmingly predominant. This means that the intensity of fishing must be very high in these waters, or that the grown fish will leave the region in question. The latter explanation, however, can hardly be of any consequence. In view of the fact that the average length of fish of the same age differs from fjord to fjord — it is less in the Søndeledfjord than at Flødevigen and in the Topdalsfjord — the cod must for the most part remain in the same fjord. Furthermore, the latest investigations by Johs. Schmidt show that the number of vertebrae in the cod is as a rule lower in the fjords than in the open sea. A preliminary examination by us of this question on the lines followed by Johs. Schmidt supports his theory. Table 5, page 50.

As the highest values of the temperature of the sea water occur approximately at the usual time of the formation of the narrow zones in the scales, this is in direct opposition to the ordinary theory regarding the formation of zones. They are generally claimed to be "winter zones" and to indicate a slow growth in both scales and fish. My first opinion regarding this problem was that certain circumstances might affect the growth adversely, and as the cod in the coastal waters of the Skagerrack might sometimes be exposed to very high summer temperatures, it might well be the case that these temperatures were higher than the optimum for the species (Dannevig 1926). It might thus happen that the negative (respiratory) processes were higher than the positive ones (assimilating), causing the formation of a "winter zone" when the temperature was at its highest.

The growth of the cod living naturally is, however, difficult to ascertain. Good information may be had by measuring age-groups from month to month, but the possibility will always be present that fish with a different growth-rate may migrate into the region in question from deeper waters for instance, or others may emigrate; and this is surely what occurs. The difference in length per month of the fish examined, (fig. 21 page 41) cannot therefore be regarded as representing the ordinary growth of one particular individual. A large length increment in the stock may just as well be the result of an invasion of a larger type of cod from deeper or shallower waters. With this limitation the length increment per month is given. Fig. 35 shows that the cod in its second calendar year, group B, has a maximum growth in September—November, but it also has a fairly good growth

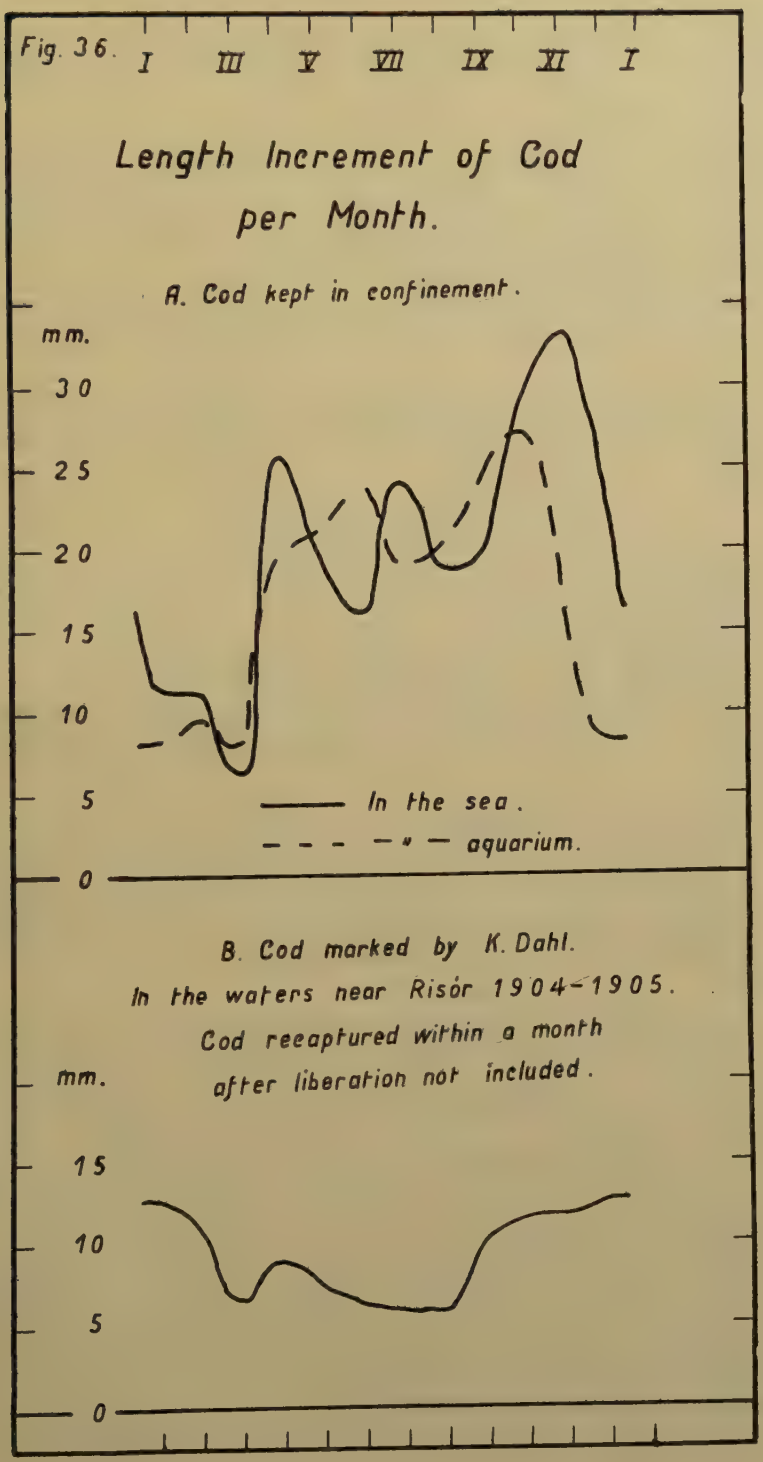


Fig. 36.
I III V VII IX XI I
Length Increment of Cod per Month.
A. Cod kept in confinement.
mm.
30
25
20
15
10
5
0
In the sea.
aquarium.
B. Cod marked by K. Dahl.
In the waters near Risör 1904–1905.
Cod recaptured within a month
after liberation not included.
mm.
15
10
5
0

in spring. Age group C. has two maxima for Flødevigen and the Topdalsfjord, in spring and autumn. In age-group D the curves are divergent.

Fig. 36 B illustrates the approximate length increment per month of the cod recaptured from Dahl's marking experiments. Minima occur in March and August, maxima in January and April, and October—December. This figure is open to discussion because the number of individuals living during certain months is low.

The total length attained by the cod at the end of the calendar year in the different waters is approximately the following:

	Søndeledfjord	Flødevigen	Topdalsfjord
2nd year	30 cm	30 cm	33 cm
3rd -	40 -	45 -	44 -
4th -	46 -	56 -	53 -

The calendar year is used in this connection as it is difficult to give the age in months, the time of spawning in these waters spreading over several months (Dannevig 1930).

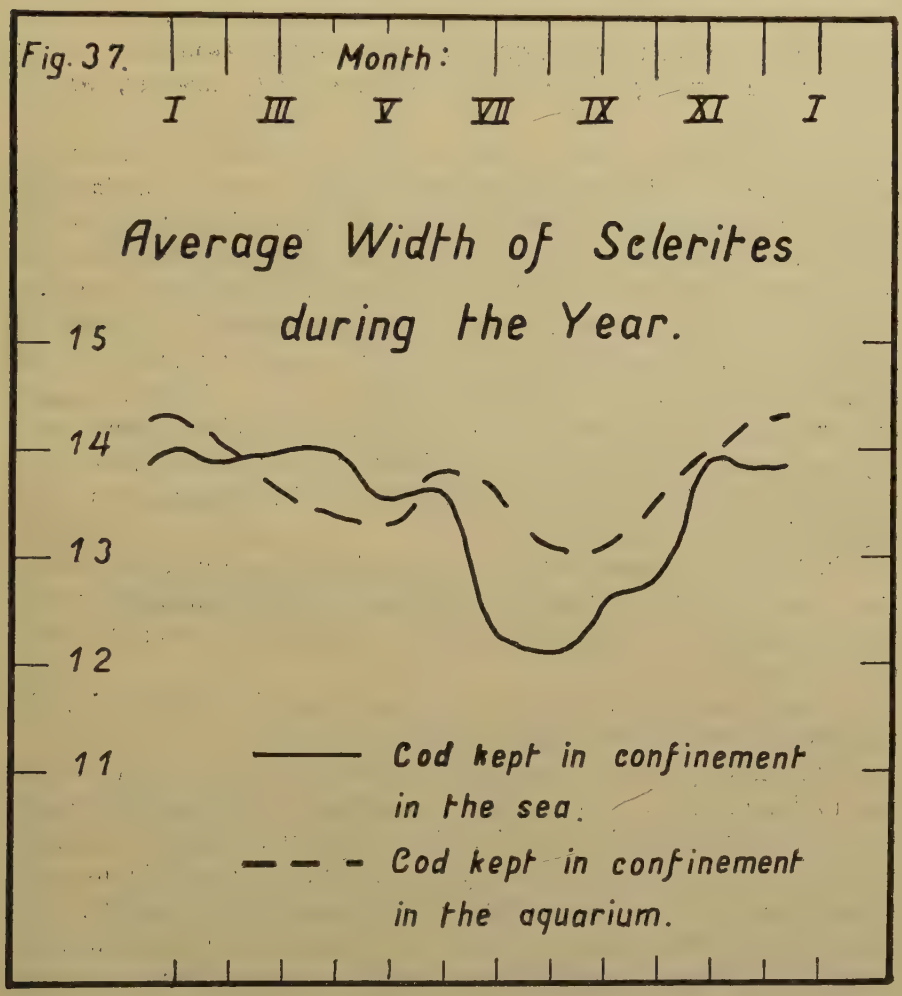
In order to attain better data bearing on the problem of zone formation, scale growth and the increase in length of the fish, cod were kept in an aquarium in the Hatchery and in rearing boxes in the sea.

Since these fish naturally had no chance of avoiding unfavourable temperatures etc., and as they were always offered ample food, though of one kind only *(Mytilus)*, our results cannot be applied directly to the cod living naturally. The results arrived at are nevertheless in general accord with the results obtained from the study of the cod at liberty.

The temperature and salinity of the seawater were observed, and the consumption of food was noted. The fish were measured & weighed every month, or every alternate month, and a few scales taken. The effect of the variation of the salinity could not be studied. The salinity is, however, hardly of any great importance so long as it is kept within reasonable limits. The feeding cod regularily hunt in waters of very different salinities.

The consumption of food was closely related to the temperature. The formation of narrow sclerites regularly occurred in March—April and in August—September in the aquarium experiment, in August—October with the cod kept in confinement in the sea. Fig. 37 gives a summary of all the experiments.

In fig. 36 A, the average length increment is given for the cod kept in captivity. The curves show a decided growth minimum in March, and a tendency to fall off in December. Secondary minima during summer, though still with a growth of 15 to 20 mm per month.



From these figures it is not possible to give a general description of the length increment of the cod in different seasons, though it seems that minimal growth occurs in March when the water is coldest, with a secondary minimum in late summer when it is warmest. That is to say, the young cod in these waters grows best at moderate temperatures.

Comparing these results with what was learnt previously as to the size of the sclerites, it is evident that the theory of the proportion-

ality between the size of the sclerites and the rate of growth cannot be maintained. The fish have fairly large length increments during the hydrographical summer, although the growth may be to some extent checked. The sclerites, however, are very narrow, and in the hydrographical winter, when the growth of the fish may be at a stand-still, the sclerites are often found to be large near the margin.

The first point may be explained by the warm season being favourable for the forming of new sclerites whose size, however, will be small.

An explanation of the occurrence of large sclerites at the margin of the scale at a time when the growth of the fish is at a stand-still is that no new sclerites are then formed. The fall of the sea-temperature during winter can be relatively rapid, and it must be remembered that the optimum temperature for the cod, 4—6° during the spawning time, is not far removed from zero when the metabolism is discontinued. If, however, the metabolism is gradually lowered by moderate low temperatures it will be reasonable to expect narrow sclerites in accordance with a slow growth of the individual. This is in agreement with my rearing experiments (Dannevig 1925) where slow-growing individuals showed small sclerites during the season in which large sclerites normally predominate.

In this way some variation in the scale structure may be expected from year to year in our waters according to the sea-temperature during winter, and some variation must also be expected in scales of fish from different waters.

It may thus occur that the zones originate in different ways by moderately low—or very high—temperatures.

But certainly, when discussing the causes of the zones, we ought not to forget that a cod is a living organism where seasonal growth may occur on the basis of an inherited seasonal rhythmus, the origin of which, however, is presumably the seasonal changes in nature—it may be light, or temperature, or the resulting food supply. The occurrence of zones in the organs of deepsea-fish (Thomson 1904, Mohr 1921) living where the seasonal differences in temperature are very small, and the occurrence of zones in scales and otoliths from fish kept in aquaria where the seawater is heated throughout the winter (Thomson 1904, Cunningham 1905) make this theory well worth further consideration.

The transparent zones in the otolith occur practically at the same time as the ordinary narrow zones in the scales, i. e. in the hydrographical summer. My first idea was that the zones might be due to modification of the calcium carbonate deposited through variation of

temperature. At my request Dr. Gulbrand Lunde (1929) examined the otoliths of cod, but the only modification of calcium carbonate found was *aragonite*.

The general opinion on the question is that the zones are due to the variation in the quantity of organic substances.

VI. Earlier investigations on the age of the cod.

It must be pointed out that the conclusions reached in these investigations on the zones in the cod scales, and in the otoliths, differ in certain respects from the general opinion on the question. It will therefore be worth while to refer to the results obtained by earlier investigators.

Regarding the age of the cod, however, no thorough investigation has been carried out elsewhere, or the data are given in such a way that they cannot readily be used for discussion.

The investigations of Hofer on the carp, of Dahl and Lea on the herring, etc., have been so convincing for the correctness of the method of reckoning the age of the fish by its scales that later students of the cod scale have limited their investigations to the study of the scales at more or less irregular intervals.

Stuart Thomson (1904) was the first to examine a considerable material for the elucidation of the method of age determination in the *gadoid* fishes, but he only gives a few figures for growth-lines in the cod scale. The occurrence of zones in fish living in deep-water where the seasonal changes in temperature are small, and the non-occurrence of zones in the scales of a whiting kept in the aquarium at Plymouth for nearly $1^1/_2$ years, caused Thomson to believe that the occurrence of zones was connected with food supply rather than with temperature.

Cunningham (1905), dealing with cod scales, states (page 131): "There is good reason for believing that the narrow sclerites are formed in winter when the temperature is low". But later on he says: "— — — it would be very difficult, from the scales alone, to form a decided conclusion as to the age of a cod". In some of the specimens examined he is uncertain as to the number of zones in the scales. He also deals with the specimen from Fulton's heated tank, in which zones still occurred in both scales and otoliths in spite of the fact that the water was prevented from reaching winter temperature.

Heincke (1908) prefers bones to scales and otoliths for estimating the age.

Damas (1909) dealing with gadoid scales (page 17) refers to Thomson's paper cited above.

He states that "Il résulte des recherches de Thomson, qui ont „été confirmées par toutes les observations subséquentes et soutenues „par tout ce que nous connaissons sur les relations entre la structure „des écailles et la croissance, que la largeur des plaquettes est en „rapport avec la rapidité de l'accroissement de la taille. L'examen „d'individus à diverses saisons montre d'autre part, que les grandes „plaquettes sont formées pendant le printemps et l'été tandis que les „éléments plus petits, voisins de la limite annuelle, sont formés pendant „l'hiver." But as previously mentioned Thomson does not deal with the cod in detail, he merely gives the number of growth lines for a few scales from two cod. Damas continues, page 17: „L'emploi des zones de structure, comme indice de l'âge et de la „croissance, repose sur l'idée que l'augmentation de la taille est »influencée par la température. Ce principe a besoin d'une „démonstration expérimentale qui, heureusement, a été fournie par „Fulton." And later page 18: "Cet exemple rend presque certain „que les différences de structure constatées dans les écailles, aux di„verses saisons de l'année sont dues aux variations de température".

Dr. Damas, however, apparently did not realise that, as previously mentioned, Fulton's experiments with the cod in the tanks must have been greatly affected by factors other than temperature. In the heated tank the mean temperature was raised from 12·3° C. to 12·9° C. only, but the rate of increment was doubled. Fulton (1904) himself says (page 170) "Of all the fishes, except the flat fishes, the codlings appeared to be least affected by the changes in temperature".

Damas is of opinion that the zones are winter zones, formed during the hydrographical winter. The occurrence in July of "winter" zones in the haddock from the deep parts of the Skagerrack is explained by the winter temperatures first reaching the depths at that time.

Regarding certain difficulties met with in the method, he states that it must be employed "avec beaucoup de reserve".

In particular he gives some analyses of the scales of cod from the North Sea. The scales show a uniform growth where the seasons are often faintly marked. Of special interest is the statement on page 94 to the effect that all the scales taken at the beginning of September showed the first narrow sclerites of autumn. As will be seen, this statement accords with our analyses of the samples from the Norwegian Skagerrack Coast.

He also cites K. Dahl's analysis of samples from the Skagerrack, previously referred to, and it is interesting to observe the statement that the scales of the cod show no narrow sclerites at the margin in November and December (page 96).

On page 98 Damas states that the appearance of the scale of the young fish (0-group) is very regular when the fish is caught in November, but often a zone formed in summer is visible (anneau d'été). As he is of opinion that this secondary zone can be distinguished from the ordinary winter zone by its morphological character, he considers that mistakes are not likely to occur when extensive material is examined. But as our studies show, this zone is very prominent. Every one of the young cod reared at Flødevigen (see page 49) had a prominent zone of small sclerites. This is also the case with the young cod taken from the sea. Moreover we have been unable to discover differences between the two sorts of zones. According to Damas the second winter zone is often difficult to detect, the later ones, however, are easily distinguished.

Damas gives no details of the data on which this conclusion is based.

Hjort (1914) refers to the investigations of Stuart Thomson and Damas. He also gives as illustration some sclerite curves and photographs. The work includes some investigations by Sund on the proportionality between the length of the fish and that of the scale & the different zones; proportionality is shown to exist. The variations which arise by taking scales from different parts of the fish are stated by Sund to be only slight. This is, as to the zones, not in agreement with the results obtained by Dannevig and Høst (1931).

Winge (1915) has studied the appearance of the cod scale in the course of marking experiments, scales being taken from the fish before liberation & after recapture. He constructs sclerite curves and shows the growth of the scale by means of graphs.

Interpreting the curves he says "Repeated observations and combinations of the same have led me to the conclusion that the maxima of the curves fall about the 1st of September, the minima during early March".

As he only gives a few graphs stated not to be "hypertypical", the validity of this conclusion cannot be tested. The figures show however, that the scales have attained minima in accordance with the time spent at liberty, and different scales from the same fish are very alike in this respect. The author believes that the secondary rings will not give much trouble when the "normal" curves have first been studied.

The degree of proportionality between the length increments of scale and fish is high. Regarding the growth of the cod he writes: "Everything seems to indicate that the rate of growth of the cod is highly dependent upon the conditions of temperature in the water, although perhaps in the main indirectly, through the effect of temperature upon the quantity of nourishment". The material forming the basis of his examination was derived from the Faeroes and Iceland.

Dannevig (1925). My own rearing experiments have already been described above. Zones appeared in the scales in early autumn; the sclerites were larger during winter, and the length of the fish caught at that season was comparatively great, showing a large increment during the calendar winter. And as the sclerites were large during winter, I came to the conclusion that rapid growth was accompanied by the formation of large sclerites. In this case, however, I was not studying the growth of the individual fish, but the averages with a considerable time interval between the observations. As slow growing individuals had narrow sclerites I formed the opinion that these features normally ran parallel.

Thompson (1926). The results of his rearing experiment have been dealt with previously. The growth increment of one particular cod constantly decreases, having been four times as great during autumn & winter as during the following summer. The growth-rate was evidently affected by adverse conditions. The scales of this individual show — according to Thompson — one winter ring and three false zones. The average growth of 4 codlings shows a relatively high length increment from October 17th to March 20th.

Regarding the cod scales Thompson writes, page 11:

"It should be stated that at sea the scales of cod seldom show very clearly the annual zoning so well marked in haddock. Even the first winter mark is often blurred or absolutely indistinguishable, and the second is very often absent altogether. This was also the case with no. 2 codling, whose growth in the tanks is quoted below. Although it showed a first winter ring (formed in the sea) and a check ("F.R.") at the time of transference (June 1923) to the tanks, there is no denotation on the scale of the second winter, which was passed through in captivity before death ensued in August 1924".

Graham (1926): On acount of the difficulty in ascertaining what is meant by a zone in the cod scale, Graham introduced a criterion based on sclerite measurements.

Sund (1927): Owing to the difficulties met with in reading the cod scales Sund introduced a new method, the combination of measurements of the fish with analyses of the scales of the fish showing

the zones most clearly. This method was later applied to the study of the Norwegian arctic stock of cod.

Graham (1929) states, page 5, that "the scale method of age determination was neither easy nor reliable without certain limitations of applications". And even for one, two and three year old fish difficulties were encountered.

In order to avoid uncertainty caused by the different ways of reading the scales, Graham renewed his attempt to find a mathematical criterion for the zones (vide Graham 1926). This method has been tried by us and works fairly well for young fish.

Graham considers the narrow zones generally to be formed during winter, but also states that narrow zones may be found throughout the whole year. From his paper (1926, page 347) it is evident that a sample from March 1924 even contained twice as many individuals with wide sclerites at the margin as individuals with narrow ones. The individuals differing from the typical form were disregarded: (Graham, 1929, page 18) "Scales with narrow zones on the margin in September, or wide zones on the margin in March cannot be classed in any age-group. No place exists in a classification on a seasonal basis for scales showing exactly the opposite phenomenon of the majority". Using this method it is shown that in the III-group codling about one in four gives an atypical result. Graham believes that the zones, if not seasonal, are at least annual. "That is to say that it is an inherent requirement of every individual that it should experience one physiological winter per annum, and that these are annually recorded on the scales, although differences for individuals in the accidents of the impinging environment do cause the reaction to take place over a wide period of time". (Page 20).

His studies of the growth rate are based on measurements of cod belonging to the year-group 1923, caught on the inner Herring Trawling Ground during the period 1923—1926. These measurements show that maximum or minimum growth occurs at irregular seasons. There was no growth from November 1924 to February 1925, a maximum in July, a low value in September, and a high value at the beginning of November. In 1926 the growth was small from January to July, with an apparent minimum in January and a maximum in April.

Regarding the bi-modal form of the curve for 1925 Mr. Graham remarks that "It may or may not be significant".

The values obtained by measuring the fish from one locality however, may, as has been previously observed, not be typical of the individual growth. In the open sea the shoals in one locality must certainly intermingle with shoals from neighbouring places.

In regard to the correlation between growth-rate and sea-temperature the author states (page 37): "The high growth-rate in July occurs somewhat earlier than the maximum surface temperature, and seems unconnected with the bottom temperature. The secondary maximum of the growth-rate at the beginning of November seems, on the other hand, to be contemporaneous with the maximum bottom temperature. If the bi-modal part of the growth-rate curve is not significant, we have a general correspondence between growth-rate and temperature of the surface, where cod do not live".

On the other hand he finds, pag. 40, that the "growth-rate and sclerite width are intimately connected", and "With regard to the relation of both to temperature, the data, so far as they go, and allowing them full significance, seem to show that high temperature is no longer a direct causative factor of the high early summer growth-rate and wide sclerites, but that in the Indian-summer a high bottom temperature results in an increased growth-rate and sclerite-width. To me, personally, the curves of Fig 19 suggest that the main maximum of growth-rate (with high sclerite width) is an inherent rhythmical response while the Indian-summer growth-rate is a response to the environment".

The lengths of scale and of fish are not in linear proportion, nor are their increments. "Within a certain range, however, the increments may be assumed to be proportional without great violence to the facts" (page 42).

Lymann Duff (1929) studied the trawle-caught cod brought in to Halifax from different banks. He considers the material to belong to "reasonably uniform stock, since they are all bank fish, and all those used were caught within a radius of less than one hundred miles." No data are given, however, on this point, and the variation found in the growth of the cod per month can just as well be the result of little differences in growth-rate on the different banks, or of changes in the population. When studying the growth of the scales during the year Duff collected the scales from fish measuring 50 to 55 cm. The probable result of this, however, was in my opinion that quickly growing as well as medium and slow-growing fish were not measured at the same time. It cannot be taken for granted whithout further investigation that the material examined was homogeneous in this respect. Moreover only a very limited number was examined, at least ten on each occasion when an examination was made (14 examinations in 14 months).

I am therefore inclined to think that Duff's results — that the growth of the cod mainly occurs during May—July, and that the growth of the scale is at a maximum in October — need further evidence.

His investigation regarding the number and quality of the circuli (rings of sclerites), however, is restricted to the material from a single fishing bank, though here also the material is limited to fish between 50 and 55 cm. It would have been better to count the circuli in all fish belonging to the same year-group. The conclusions reached are that the narrow sclerites are formed in August—December, and predominate near the margin till spring; the broad sclerites are formed chiefly in March—July. He is of the opinion that the age of the cod cannot be accurately determined from the scales beyond the fourth or fifth year of the fish.

As to the otoliths, the transparent zone in our waters was quite regularly formed during the hydrographical summer, at the same time as the narrow zone is normally formed in the scale.

The correspondence between narrow sclerites in the scale and clear zones in the otolith has been previously pointed out by Winge, 1915, though he was of the opinion that the narrow sclerites and the clear zones were both formed during winter.

In the literature on the age of the cod the transparent zone in the otolith is generally called the "winter zone" or winter ring (Cunningham 1905, and others). For the Norwegian Skagerrack cod this term is not significant. It may be better termed simply "the transparent zone" and the time at which it is formed should be ascertained from the particular material in question.

In the case of the plaice, Reibisch, Cunningham and others found that the transparent zone was formed in late summer. Reibisch was of opinion that the new opaque zone was formed during winter and spring. Cunningham, however, maintained that the transparent zone persisted at the margin of the otolith till spring, and that the opaque zone was formed in spring and summer.

It will appear that the method of age determination of the cod has nowhere been established by a thorough investigation. The results obtained in the study of other species have been kept in mind during the work on the cod, and when difficulties were met with they were generally regarded as something extraordinary.

As to the problem of the determination of the age of the cod by means of scales and otoliths all workers agree that the method is useful. But on a number of fundamental points there are just as many divergences of opinion as there are investigators.

In the present state of things it will surely be impossible to give a general statement as to what occurs—and why— when the zones are formed in the scales and otoliths.

In order to elucidate the general problem of the growth of the cod and the scale, further experiments are needed.

But our investigations have demonstrated that the age of the cod in our waters certainly can be computed by the scales — and particularly by the otoliths. And surely this will also be the case with the cod from other waters where difficulties are met with. But it is of importance to examine the method of age-determination on the material in question; — especially to find out at what season the zones are formed.

In this way the method of age-determination of the cod would surely gain in accuracy, and the results obtained by workers in all parts of the area covered by *Gadus callarias* would become comparable, to the great advancement of the biological study of this species.

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VIII.

TABLES.

Tab. I A.

Rødsfjord
in Søndeledfjord.

m	1928	1929		1930		
	18/9	19/9	2/12	14/7	25/9	24/11
			Temperature °C.			
0	15.0	15.1	3.4	20.0	12.3	3.0
	15.1	13.5	6.8	17.5	14.0	7.3
10	15.2	13.8	6.9	14.3	14.0	8.4
	—	13.8	7.1	11.5	14.9	10.6
20	12.8	—	—	—	—	—
	—	13.3	11.5	8.1	12.4	11.0
30	6.7	—	—	—	—	—
	—	5.6	8.1	5.9	6.0	10.3
40	—	—	—	—	—	—
	—	5.5	5.6	5.8	5.8	6.2
50	5.3	—	—	—	—	—
	—	5.4	5.5	5.7	5.8	5.8
60	—	—	—	—	—	—
70	5.3	—	—	—	—	—
	—	5.4	5.4	5.7	5.7	5.8
80	—	—	—	—	—	—
			Oxygen cm³ pr. l.			
0	6.5	6.1	7.9	6.4	7.0	7.5
	6.4	5.6	7.0	6.4	6.0	6.6
10	6.4	5.4	6.8	6.1	5.8	6.1
	—	5.4	6.6	6.2	5.7	5.5
20	6.7	—	—	—	—	—
	—	5.2	4.5	5.4	5.0	5.4
30	4.6	—	—	—	—	—
	—	4.3	4.0	4.4	4.1	5.1
40	—	—	—	—	—	—
	—	2.8	2.5	5.8	4.8	3.8
50	4.0	—	—	—	—	—
	—	1.4	0.8	4.4	4.2	3.7
60	—	—	—	—	—	—
70	2.3	—	—	—	—	—
	—	0.1	0.0	3.8	2.5	2.4
80	—	—	—	—	—	—
			Salinity ‰.			
0	26.24	29.74	5.72	20.28	7.09	17.77
	27.01	31.17	24.63	24.09	25.62	31.55
10	29.45	31.83	26.09	28.53	26.31	32.63
	—	32.09	27.41	30.50	27.56	33.46
20	31.98	—	—	—	—	—
	—	32.29	32.81	32.23	31.02	33.78
30	33.87	—	—	—	—	—
	—	33.58	33.51	33.73	33.51	33.86
40	—	—	—	—	—	—
	—	33.77	33.75	33.95	33.60	33.86
50	34.00	—	—	—	—	—
	—	33.78	33.96	33.91	33.71	33.91
60	—	—	—	—	—	—
70	34.04	—	—	—	—	—
	—	33.91	33.96	33.91	33.87	33.91
80	—	—	—	—	—	—

Tab. I B. **Topdalsfjord.**

Inner basin.

m	1928			1929			1930		
	20/6	26/9	24/11	6/7	26/9	26/11	8/7	17/9	18/11
				Temperature C°					
0	14.7	11.3	5 6	17.4	13.7	4.1	14.7	14.1	10.4
	11.4	13.2	7.7	11.7	13.7	7.3	11.5	16.2	11.0
10	10.0	13.8	9.5	9.9	13 5	7.5	10.5	15.8	11.5
	9.4	14.0	10.9	8.5	13.1	8 3	9.5	15 3	11.6
20	8.1	14.1	11.8	7.9	12.7	9.0	10.3	15.3	11.5
30	5.1	12.4	11.2	6.9	11.4	11.2	6.6	10.6	11.3
40	5.1	5.2	5.3	5.9	6.1	6.2	6.1	6.2	6.4
50	5.0	5.1	5.2	6 3	6.3	6 3	6.1	6.1	6.1
60	5.0	5.2	5.2	6.3	6,3	6.3	6.1	6.1	6,2
				Oxygen cm³ pr. l.					
0	6.9	7.3	8.9	6.3	7.6	9.1	6.3	7.0	5.6
	7.7	6.9	6.2	6.7	6.5	6.7	6.9	5.9	5.5
10	7.7	6.7	6.0	8.0	5.8	6 7	6.8	5.6	5.5
	6 8	6.7	5.6	6.8	5.8	6.4	7.0	5.5	5.7
20	7.2	6.2	5.1	6.7	5.8	6.2	6.9	5.6	5.6
30	5.9	5.1	5.0	6.4	5.5	5.0	5.3	4 9	5.5
40	6.0	5.1	3.5	4.6	3.9	3.2	4.7	4.1	3.5
50	6.5	4.9	3.4	3.2	1.7	1.3	4.1	3.4	2.9
60	6.0	3.7	2.6	2.4	1.2	0.9	3.9	2.6	2.0
				Salinity ‰.					
0	18.06	15.28	0.59	16.92	4.94	0.95	27.29	2.56	33.86
	27.38	26.55	27.79	30.82	29.97	28.04	30.75	30.81	33.96
10	29.92	29.16	30.16	31.76	31.64	28.91	31.76	31.56	34.20
	30.46	30.61	29.61	32.79	32.41	30.12	32.57	31.83	34.27
20	31.08	31.83	32.95	33.21	32.72	30.64	30.86	32.03	34.33
30	34.11	33.62	33.66	33.66	33.37	33.66	34.18	33.48	34.34
40	34.20	34.25	34.09	34.47	34.34	34.13	34.47	34.47	34.34
50	34.31	34.45	34.11	34.63	34.51	34.52	34.47	34.47	34.36
60	34.31	34.45	34.11	34.63	34.51	34.49	34.65	34.49	34.36

Tab. I C. **Kristiansandsfjord.**
Outside Topdalsfjord.

m	1928			1929			1930		
	20/6	26/9	23/11	6/7	27/9	26/11	3/7	17/9	18/11
				Temperature °C.					
0	12.3	13.2	5.0	15.4	13.5	4.6	16.1	14.3	6.9
	11.3	—	—	11.6	—	—	—	—	—
10	10.9	13.4	10.0	9.9	13.9	7.7	10.5	14.8	10.4
	—	—	—	9.6	—	—	—	—	—
20	8.4	13.5	9.8	9.1	13.8	8.7	9.16	14.9	10.4
	—	—	—	8.9	—	—	—	—	—
30	7.0	13.8	9 8	—	13.9	10.0	8.46	15.0	10.4
40	7.5	13.6	7.2	—	13.3	10.6	7.77	15.0	10.7
50	6.2	13 6	9.7	7.9	12.6	10.0	7.49	15.0	10.6
75	6.3	7.3	9.9	6.7	9.4	10.3	6.9	6.8	10.5
100	—	6.9	9.6	6.2	7.7	9.7	6.6	6.5	10.4
125	5.5	6.8	9 3	—	7.2	8.3	6.3	—	—
150	—	—	—	—	—	—	—	6.4	9.8
				Oxygen cm³ pr. l.					
0	8.0	7.2	9.1	6.6	7.2	8.6	6.5	6.8	8.1
	7.0	—	—	6.6	—	—	—	—	—
10	7.6	6.5	6.0	6.8	6.3	8.4	6.2	6.6	5.9
	—	—	—	7.0	—	—	—	—	—
20	6.9	6.9	6.0	6.7	6.0	6.7	6.4	5.7	6.0
	—	—	—	6.8	—	—	—	—	—
30	7.1	6.0	5.9	—	5.8	6.1	6.4	5.5	6.3
40	7.0	6.8	6.3	—	5.8	NB.	6.4	5.8	6.0
50	7.0	5.2	5.9	6.3	5.6	6.3	6.3	5.3	5.9
75	6.8	6.0	5.9	6 3	5.8	6.0	6.3	5.9	5.9
100	—	6.0	5.8	6.2	6.0	6.0	6.3	6.2	5.8
125	7.2	5.9	5.6	—	5.8	5.7	6·2	—	—
150	—	—	—	—	—	—	—	6.2	6.6

Tab. I C (cont.)

Salinity ‰.

m	1928			1929			1930		
	20/6	26/9	23/11	6/7	27/9	26/11	8/7	17/9	18/11
0	11.24	18.53	1.17	14.78	17.05	6.51	23.06	12.32	16.64
	29.54	—	—	31.18	—	—	—	—	—
10	29.83	26.22	32.05	32.43	31·08	28.80	33.37	31.27	34.25
	—	—	—	32.88	—	—	—	—	—
20	32.23	27.72	33.26	32.86	32.48	30.75	33.80	31.65	34.25
	—	—	—	33.04	—	—	—	—	—
30	33.08	32.21	33.77	—	32.79	32.72	34.02	31.92	34.25
40	33.64	33.93	NB.	—	33.30	32.81	34.23	32.94	34.31
50	33.95	34.11	34.00	34.14	33.62	33.64	34.52	33 24	34.29
75	34.20	34.78	34.00	34.51	34.51	34.49	34.70	34.74	34.56
100	—	35.19	34.29	34.96	34.63	34.83	NB.	34.83	34.58
125	34.69	35.23	34.65	—	34.85	34.90	35.07	—	—
150	—	—	—	—	—	—	—	34.99	34.56

Tab. II. Average width of sclerites for each centimetre of length of the fish.

The central part of the scale only considered.

A. Søndeledfjord 1927.

	Length of fish in cm																	Number of fish examined
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
January..	11.8	10.3	10.1	*9.9*	*9 9*	11.8	13.7	**14 8**	14.4	14.3	13 6	13.8	12.9	13.3	14.3	14.7	14.6	17
February.	12.9	10.3	*9.8*	10.3	11.6	11.8	11.9	13.2	13.3	13.1	13.2	13.4	14.0	**15.1**	14.3	14.1	14.4	28
March ...	11.7	9.6	*9.4*	9.9	10.4	11.1	12.3	12.6	13.5	13.2	13.9	13.7	**14.1**	13.4	13.7	13.8	13.9	66
April	12.1	9.8	*9.1*	10.0	10.4	11.1	11.9	12.8	13.6	13.5	13.8	14.3	13.9	14.0	**14.5**	14.3	14.1	55
May	13.0	10.2	10.0	*9.9*	10.4	11.8	12.3	12.3	13.4	13.3	13.3	14.0	13.9	14.4	**14.9**	13.9	13.9	48
June.....	12.3	10.0	*9.6*	9.8	10.6	10.9	11.6	11.1	12 6	12.9	13.2	13.8	13.6	13.6	13.4	14.2	**15.1**	92
July.....	12.4	10.1	*10.0*	10.3	11.0	11.5	12.7	13.1	13.5	13.7	13.8	14.4	14.9	16.1	16.8	**17.1**	17.1	59
August ..	12.3	*9.7*	*9.7*	10.7	12.4	12.7	13.6	13.6	14.3	16.0	16.0	15.8	16.2	13.7	16.6	17.3	**18.4**	23
Septbr. ..	12.5	10.3	*9.4*	9.6	10.5	11.8	12.0	12.4	13.2	13.4	13.4	**13.7**	13.0	13.1	13.4	13.4	13.3	23
October..	10.6	9.2	*8.8*	10.2	11.4	12.1	13.2	13.9	14.0	13.7	13.7	13.5	14.4	15.8	**16.3**	15.5	14.7	13
November	*9.2*	10.2	10.2	13.4	12.8	14.4	15.2	**16.6**	14.2	16.2	15.6	13.4	12.8	11.0	14.8	12.4	13.6	5
December	12.4	11.0	*9.8*	10.8	11.3	12.0	13.8	15.4	17.1	18.4	18.4	**18.8**	18.1	16.9	16.3	15.4	15.0	26

Tab. II. Average width of sclerites for each centimetre of length of the fish.

The central part of the scale only considered.

B. **Søndeledfjord 1928.**

	Length of fish in cm																	Number of fish examined
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
January . .	12.8	12.1	12.2	*11.0*	11.1	11.2	11.5	13.6	13.5	14.3	14.4	14.9	14.7	**15.0**	14.4	12.9	15.0	55
February .	15 2	13.2	10.6	10.5	*10.3*	10.7	11.6	12.4	14.1	14.7	15 6	15.4	15.4	**15.8**	14.3	14.6	15.2	20
March . . .	13.7	11.3	11.2	11.6	11.2	*10.9*	11.6	11.9	12.4	14.3	14.2	13 8	14.9	15.6	15.2	15.8	**16.5**	27
April . .	13.9	11.1	10.3	*9.4*	9.6	10.9	12.0	12.0	12.8	13.6	14.4	14.5	14.7	15.7	15.6	**16.3**	15.9	41
May	13.4	11.8	10.7	10.8	*9.5*	11 5	12.2	12.5	13.4	13.5	14 5	15.1	14.9	15.2	15.2	**15 3**	14.7	78
June	13.4	10.9	10.3	*10.0*	10.4	11.3	11.6	12.6	13.7	14.0	14.3	**14.7**	14 6	14.3	14.4	13.9	13.3	133
July	12.8	10.6	*10.2*	10.5	10.5	11.1	11.8	12.7	13.1	13.7	14.1	14.3	14.5	14.5	**14.8**	14.3	14.5	67
August . .	13.9	12.2	10.9	*10.7*	11.6	11.2	11.7	11.9	12.0	13.2	14.4	15.1	16.1	**16.5**	16.4	16.1	16.4	22
Septbr. . .	12.8	10.8	*9.3*	9.5	11.0	11.1	11.7	13.3	15.1	16.0	16.4	15.8	15.8	16.2	15.9	**16 6**	15.3	23
October .	15.5	13.1	11.4	*9.5*	9.6	10.1	11.1	11.8	13.1	13.5	14.3	14.6	14.6	13.4	14.3	14.0	**16.4**	10
November	16.1	13.3	11.1	11.0	11.0	*9.6*	11.6	12.1	12.9	13.4	14.3	15.0	15.6	**16.5**	16.0	16 4	16.1	21
December	16.1	12.6	10.9	*10.0*	*10.0*	10.6	11.8	12.1	13.2	13.0	14.6	15.8	**16 5**	15.6	15.5	15.0	15.3	31

Tab. II. Average width of sclerites for each centimetre of length of the fish.

The central part of the scale only considered.

C. **Flødevigen 1926 & 1927.**

	Length of fish in cm																	Number of fish examined
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1926																		
November	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
December	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1927																		
January ..	12.6	10.6	9.7	9.1	*9.0*	9.8	10.3	11.4	12.5	13.5	13.9	14.0	14.1	11.7	13.5	13.1	**14.7**	61
February	13.4	11.1	9.6	9.3	*8.0*	9.4	10.1	12.0	13.0	13.7	13.3	13.4	13.8	14.1	**14.8**	13.8	13.4	10
March ...	12 8	10.4	9.7	9.6	*9.4*	10.4	11.5	12.0	13.2	14.0	13.9	13.8	13.4	13.4	13 6	**14.6**	14.4	19
April	12.2	10.7	9.8	*9.2*	9.8	11.1	12.1	12.6	14.1	15.1	15.7	**16.0**	14.7	13.0	12.4	13 2	13.8	16
May	12.3	10.5	9.7	9.7	*9.5*	10.0	10 8	11.4	12.3	12.9	13.8	13.7	13.2	**14.3**	13.2	12.9	13.4	23
June ...	13.6	11.6	10.6	10.4	*9.4*	10.4	11.4	12.8	13.4	14.8	15.0	13.6	14.4	15.8	16.4	**16 8**	14.4	5
July	16.5	11.5	12.0	9.5	*9.0*	9.5	10.0	10.5	11.0	10.0	10.5	11 0	11.5	13.0	**13.5**	12.0	12.5	2
August ..	11.0	10.7	11.0	*9.9*	10.0	10.0	10.9	11.3	12.8	14.3	**15 5**	14.4	13.9	13.4	14.0	14.3	13.3	7
Septbr. ..	12.2	9.8	*8.9*	9.0	9.3	10.3	10.1	11.2	12.5	14.8	**16.0**	15.3	14.3	13.5	13.5	13.4	14.1	16
October	13.5	11.6	10.5	9.6	*9.2*	10.4	11.2	12.2	14.2	15.0	14.2	14.0	13.9	13.4	14.0	14.3	**15.7**	16
November	11.3	10.6	*9.6*	*9.6*	10.1	11.6	12.6	13.2	14.7	**16 6**	15.6	15.6	15.9	15.3	15.6	15.9	15.8	11
December	12.3	10.8	*8.8*	10.0	10.3	11.0	12.3	14.1	14.2	15.4	17.1	**17.8**	17.4	17.8	17.4	17.6	16 8	13

Tab. II. Average width of sclerites for each centimetre of length of the fish.

The central part of the scale only considered.

D. **Topdalsfjord 1926 & 1927.**

	Length of fish in cm																	Number of fish examined
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1926																		
October .	14.9	11.7	10.8	*9.7*	9.9	10.5	11.4	12.6	13.7	14.7	15.6	16.1	16.9	**17.2**	16.8	16.8	16.8	82
November	15.7	12.3	10.4	*10.2*	10.5	11.2	11.5	12.5	13.1	13.8	14.4	16.5	17.4	**18.2**	18.2	18.0	18.0	93
D cember	16.8	12.6	11.3	9.9	*9 4*	10.5	11.2	12.0	13.1	14 1	14.9	15.8	15.9	15.2	16.5	16.1	**17.0**	29
1927																		
January . .	16.4	12.2	10 9	*10.2*	10.6	11.5	12.7	12.8	13.1	13.8	14.3	14 0	15.1	15.1	15.1	15.2	**15.8**	15
February .	16.5	12.4	10.8	10.8	*10.1*	10.2	11.4	13.9	15.2	16.3	16.9	**17.2**	17.1	16.6	16.0	16.7	15.4	18
March . . .	15.4	11.6	10.7	*9.8*	*9 8*	10.5	11.7	12.4	13.0	13.7	14.9	15.3	15.8	15.9	15.6	16.1	**16 5**	24
April . . .	15.0	12.1	10.4	*9.4*	10.2	10.9	11.4	12,3	13.2	14.0	14.6	15.2	15.3	15.2	**15.8**	15.1	15.2	28
May	13.9	10.8	*9.5*	10.2	10.9	11.5	12.5	13.6	14.9	15.9	16.2	**16.7**	16.7	15.9	15.3	15.2	15.0	31
June	16.1	13.0	10.8	10.3	*9.7*	11.0	11.7	12.2	13.0	14.2	14.8	15.4	**16.3**	15.8	15.6	15.7	15.0	30
July	13.7	11.2	*9.8*	10.1	10.3	11.0	12.0	13.4	14.5	15.2	15.7	**16.1**	15.8	15.8	15.1	15.4	15.0	40
August . .	14.1	10.7	9.9	*9.6*	10.9	12.0	12.7	13.8	13.8	14.5	15.2	15.8	15.7	15.9	16.2	16.6	**16.7**	36
Septbr. . . .	13.8	11.5	*9.8*	*9.8*	10.1	10.2	13.5	14.5	15.9	16.9	17.1	17.2	16.6	**18.3**	18.3	18.0	16.7	10
October . .	18.0	13.5	10.2	*9.0*	12.0	12.5	13.5	13.5	12.5	13.0	13.0	12.2	10.3	12.5	14.8	**15.5**	15.0	4
November	13.8	10.9	9.8	*9.2*	9.5	11.5	11 9	13.7	13.9	14.5	15.8	17.1	17.7	18.5	**19.9**	18.6	17.4	10
December	17.9	12.4	9.5	*8.3*	9.5	11.2	12.8	13.0	15.2	17.0	18.0	**18.8**	17.9	17.9	16.6	15.7	15.4	11

Tab. III. Average width of sclerites at different distances from the margin of the scale, the distances expressed as the corresponding length increments of the fish.

Cod less than 40 cm only included.

A. Søndeledfjord 1927.

	Distance of sclerite from margin of scale, in cm of fish length:														Number of fish examined
	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
January	14.4	15.2	16.6	14.5	14.6	15.5	14.9	14.7	15.1	15.7	15.6	**16.3**	16.0	12.4	14
February	14.7	14.5	14.6	14.1	14.3	14.3	15.0	16.9	17.2	**17.3**	17.1	16.1	16.0	14.2	22
March	13.0	13.6	14.4	14.9	15.5	15.9	15.8	**16.6**	16.5	16.1	15.4	15.0	14.4	13.2	60
April	13.2	13.6	13.8	13.7	13.7	13.6	15.4	15.3	15.7	16.2	15.5	14.7	13.5	11.7	47
May	14.0	13.1	12.3	13.4	14.7	15.1	15.1	15.8	14.9	14.2	14.4	13.3	11.5	10.8	29
June	13.4	13.4	13.8	14.1	15.2	15.8	16.0	16.2	16.1	16.5	16.3	16.2	15.1	13.8	76
July	14.7	14.8	14.8	15.8	16.1	17.6	19.2	19.2	19.9	20.1	19.4	18.3	17.1	14.4	51
August	16.2	16.1	16.5	17.5	18.7	19.8	20.3	20.1	19.5	18.5	17.5	16.5	13.5	11.2	20
September	14.2	15.0	14.8	14.8	14.4	15.8	16.2	17.0	17.4	16.8	14.6	14.6	13.3	11.2	16
October	15.9	15.9	17.4	16.3	15.4	14.8	15.5	15.5	16.0	15.4	14.0	13.4	14.5	13.7	10
November	19.0	17.6	15.2	14.2	13.0	12.2	11.0	11.2	13.8	15.6	15.6	15.6	15.8	15.2	5
December	19.4	19.7	18.6	17.1	15.0	14.4	15.1	15.4	16.0	17.0	18.2	19.1	18.8	17.4	26

Tab. III. Average width of sclerites at different distances from the margin of the scale, the distances expressed as the corresponding length increments of the fish.

Cod less than 40 cm only included.

B. Søndeledfjord 1928.

	Distance of sclerite from margin of scale, in cm of fish length														Number of fish examined
	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
January	14.9	14.5	14.5	14.0	14.7	14.9	14.5	15.2	15.9	17.2	18.0	17.9	**18.2**	17.3	49
February	15.7	15.8	14.0	14.7	13.8	13.8	15.5	16.1	15.9	16.5	17.8	**18.2**	17.1	16.0	13
March	14.4	13.8	15.1	15.0	14.0	14.7	15.4	16.1	17.0	17.7	17.7	**18.8**	16.8	15.9	21
April	15.1	13.4	12.9	12.3	12.6	15.5	16.1	16.3	17.4	17.0	**19.4**	18.8	16.6	15.3	14
May	14.3	15.3	15.2	15.7	15.8	16.2	17.2	17.0	**18.1**	17.8	17.2	16.3	15.7	13.8	46
June	13.2	14.2	15.0	15.5	16.4	16.2	16.6	**17.2**	**17.2**	17.0	15.9	15.3	14.1	12.1	57
July	16.2	15.9	16.3	16.9	17.0	16.6	**17.0**	16.8	16.8	16.0	15.4	14.4	13.6	11.2	33
August	16.1	17.2	18.1	17.9	17.1	17.4	17.5	17.9	17.3	17.9	17.3	16.5	14.7	10.2	14
September	16.1	16.5	18.2	18.3	17.5	18.7	19.1	18.9	18.3	16.8	14.5	13.8	11.9	*9.2*	15
October	15.6	16.9	18.9	18.6	18.1	17.7	18.4	15.9	14.9	13.3	12.1	12.4	*11.9*	10.4	7
November	15.0	16.3	17.4	17.1	16.8	16.8	17.0	16.1	15.8	15.2	14.0	14.6	*13.1*	13.8	18
December	15.2	16.0	17.3	17.2	16.3	16.7	16.4	15.5	13.7	13.1	*12.3*	12.5	12.5	11.9	24

Tab. III. Average width of sclerites at different distances from the margin of the scale, the distances expressed as the corresponding length increments of the fish.

Cod less than 40 cm only included.

C. Flødevigen 1926 & 1927.

	Distance of sclerite from margin of scale, in cm of fish length														Number of fish examined
	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1926															
November	15.0	15.7	16.0	15.6	14.7	13.9	17.7	14.9	15.0	15.3	15.7	16 8	**18.1**	15.9	32
December	15.3	14.9	14.9	15.2	14.0	13.8	14.8	15.0	14.7	15.2	16.7	**18.3**	18.3	16.8	19
1927															
January	14 7	15.4	14.5	13.8	13.0	12.6	12.8	13.5	14.6	16.0	**17.1**	17.0	15.1	11.9	59
February	15.3	14.7	14.2	13.1	13.0	11.8	12.5	13.2	15.7	16.9	**17.7**	15.5	14.0	12.8	9
March	15.6	13.6	13.1	13.6	14.2	15.0	16.0	17.4	**19.2**	17.4	16.1	15.0	14.8	13.1	19
April	13.9	13.8	14.4	14.9	15.2	17.5	19.4	**19.8**	19.7	19.6	18.7	17.7	16.9	14.8	14
May	11.2	13.3	13.8	14.5	15.8	16.9	**16.9**	16.7	16.2	15.3	15.2	14.7	14.6	13.3	18
June	13.0	14.7	15.7	16.3	**18.3**	18.0	17.7	17.3	14.7	16.0	17.3	16.7	15.7	13.3	3
July	14.0	13.0	13.0	14.0	**20 0**	18.0	16.0	15.0	14.0	12.0	12.0	12.0	12.0	*7.0*	1
August	12.0	12.3	12.5	13.7	14.2	14.5	13.7	14.5	15.3	15.7	15.5	16 3	15.2	*9.8*	4
September	16.2	15.0	14 9	16.2	15.2	15.8	16.8	17.0	17.2	16.4	15.9	14.5	*13.5*	*10.8*	10
October	17.9	17.4	16 2	16.6	16.3	16.0	17.2	18.2	17.7	16.8	14.0	*9.5*	13.9	13.9	6
November	15.0	14.9	16.0	17.1	15.4	14.0	13.6	15.2	15.7	16.3	*15.0*	15.2	17.0	13.9	7
December	16.5	16.3	16.8	15.7	16.7	16.3	15.9	16.3	17.3	18.2	17.9	17.0	17.3	15.3	10

Tab. III. Average width of sclerites at different distances from the margin of the scale, the distances expressed as the corresponding length increments of the fish.

Cod less than 40 cm only included.

D. **Topdalsfjord 1926 & 1927.**

	Distance of sclerite from margin of scale, in cm of fish length														Number of fish examined
	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1926															
October	17.6	17.3	17.7	17.9	17.7	17.1	16.8	16.0	14.9	14.5	14.7	15.3	15.7	**15.8**	47
November	18.8	18.5	18.1	17.2	15.7	15.0	14.7	14.4	15.0	15.6	16.8	**18.0**	16.9	15.9	74
December	18.2	17.8	17.5	16.8	16.1	15.5	14 6	13.5	14.3	15.8	17.3	**17.4**	15.9	15.3	17
1927															
January	15.1	13.3	11 7	14.6	18.0	18.3	15.7	17.4	**18.3**	17.0	16.0	17.0	16.0	10.7	3
February	16.3	16.0	15.3	14.9	14.7	16.1	16.3	16.5	16.5	16.2	16.8	17.2	16.0	12.2	8
March	17.3	16.3	14.8	14.7	15.4	16.0	17.0	16.2	14.9	14.5	14.7	13.6	13.0	11.6	11
April	18.2	16.2	15.4	15.1	14.7	15.2	15.0	15.9	15.8	16.5	16.4	15.7	*15.0*	14.1	10
May	15.4	14.9	14.6	15.3	15.9	16.2	15.5	15.3	14.4	13.5	*12.8*	13.1	14.0	13.8	13
June	14.8	15.3	15.1	14.6	14.8	15.3	15.3	14.9	*14.4*	15.5	16.2	17.2	**17.2**	13.2	20
July	14.4	14.8	14.3	14.9	15.7	16.1	15.3	15.6	16.2	16.1	15.9	**16.5**	15 4	14.1	20
August	15.0	15.5	15.6	15.5	17.0	17.6	18.2	18.3	18.2	**19.0**	18.9	17.0	15.6	13.5	18
September	14.7	16.7	17.4	17.7	18.2	17.9	18.5	18.3	**18.6**	18.5	16.5	14.9	14.5	*12.2*	7
October	13.0	13.5	11.5	14.5	17.0	17.5	14.5	13.0	15.5	15.5	13.0	*12.5*	13.5	13.0	2
November	18.0	19.5	21.0	21.0	19.5	20.5	19.5	18.0	16.0	15.0	*14.0*	*14.0*	16.0	14.0	2
December	17.5	15.5	16.5	17.3	18.3	19.2	18.3	17.8	17.2	*17.0*	17.3	17.0	16.7	14.8	4

Tab. IV. Average width of sclerites at different distances from the margin of the scale, the distances expressed as the corresponding length increments of the fish.

Cod 40 cm and more.

A. Søndeledfjord 1927.

	Distance of sclerite from margin of scale, in cm of fish length														Number of fish examined
	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
January	15.0	13.6	13.0	12.3	13.3	13.0	11.0	12.6	10.6	10.6	11.0	12.6	15.0	11.3	3
February	11.3	12.1	12.3	12.5	11.3	11.3	10.3	12.1	13.5	13.0	12.3	11.7	11.0	9.0	6
March	11.1	13.0	12.9	14.1	16.0	15.7	15.9	15.0	16.0	16.6	16.3	15.1	13.5	11.8	6
April	13.5	13.4	13.8	13.3	14.8	14.8	15 0	15.3	16.1	17.6	16.6	15.0	14.5	12.0	8
May	12.5	12.8	12.9	13.7	13.7	13.8	14.0	15.0	14.4	14.3	13 5	12.6	12.3	10.7	19
June	14 2	16.1	16.1	15.4	15.4	15.5	15.4	14.7	14.6	14.6	15.1	15.0	13.3	12.5	16
July	16.1	16.0	16.8	15.4	14.7	14.4	13.5	13.4	14.4	14.4	16.2	15.0	14.1	11.5	8
August	12.0	13.3	14.6	14.3	15.3	17.3	18.3	13.7	15.0	16.0	16.0	15.6	13.7	13.0	3
September	15.0	14.0	14.1	14.9	16.1	15.0	14.9	15.6	15.0	12.6	13.6	13.3	10.9	10.4	7
October	9.7	13.0	14.3	16.6	16.0	16.0	14.7	16.6	14.0	11.3	12.3	13.3	11.3	11.0	3
November	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
December	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0

Tab. IV. Average width of sclerites at different distances from the margin of the scale, the distances expressed as the corresponding length increments of the fish.

Cod 40 cm. and more.

B. **Søndeledfjord 1928.**

	Distance of sclerite from margin of scale, in cm of fish length.														Number of fish examined
	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
January	16.3	16.8	16.2	14.5	14.7	13.0	12.8	15.0	12.5	14.3	14.3	13.5	14.0	11.2	6
February	12.7	12.1	12.6	13.1	13.0	13.0	11.1	10.1	9.6	9.3	11.8	12.8	11.8	10.3	7
March	17.2	15.3	15.5	14.3	12.1	13 3	14.9	14.0	14 5	12.3	13.0	12.9	15.7	14.3	6
April	13 9	13 2	12.7	12.9	13.3	13.0	12.0	12.7	12.2	12.5	13.0	13.0	13.3	12.8	27
May	13.4	13.3	12.8	13.5	14.5	14.0	13.8	13.3	13.1	12.9	13.5	12.3	11.8	11.1	32
June	13.1	12.9	12.1	12.4	12.0	12.3	12.0	12.3	12.2	12.5	12.5	11.8	11.3	10.5	76
July	13.0	12.8	12.8	13.1	12.7	12.6	13.8	13.8	13.7	13.4	13.5	12.8	11.4	10.4	34
August	15.4	15.1	14.6	16.6	15.8	16.2	15.9	14.5	14,5	15.4	14.6	14.1	12.2	8.7	8
September	16.4	14.4	15.1	15.7	16.3	16 4	14.5	14.2	16.3	15.6	13.7	11.9	12.4	9.6	8
October	11.0	12.0	12.7	12.3	12.7	15.0	13.3	9.3	10.3	12.3	8.7	9.3	9.3	8.7	3
November	14.0	13.7	17.3	14.3	16.0	14.7	11.7	18.3	18.0	17.0	17.3	16.7	13.3	12.3	3
December	11.9	11.0	13.6	13.1	12.7	11.4	11.6	11.1	12.3	11.7	10.7	11.9	10.3	10.9	7

Tab. IV. Average width of sclerites at different distances from the margin of the scale, the distances expressed as the corresponding length increments of the fish.

Cod 40 cm and more.

C. Flødevigen 1926 & 1927.

	Distance of sclerite from margin of scale, in cm of fish length														Number of fish examined
	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1926															
November	16.4	14.8	15.4	15.8	15.6	15.0	14.4	12.8	12.8	15.4	18.6	16.8	17.6	14.4	5
December	15.0	16.0	20.0	22.0	22.0	21.0	21.0	19.0	17.0	19.0	20.0	19.0	15.0	12.0	1
1927															
January	11.5	16.0	15.5	15.5	13.0	12.0	12.5	14.5	15.0	14.5	14.0	14.5	15.0	14.5	2
February	11.0	13.0	17.0	19.0	21.0	21.0	20.0	19.0	20.0	20.0	21.0	18.0	14.0	12.0	1
March	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
April	12.0	11.5	14.0	17.0	16.5	19.0	18.5	19.5	17.5	17.5	17.0	17.0	16.5	16.5	2
May	17.4	17.6	20.0	16.3	16.3	20.4	18.5	17.2	17.8	18.2	17.8	16.0	15.2	15.6	5
June	18.5	21.0	19.5	18.5	19.0	19.5	18.5	20.0	19.5	17.5	16.5	14.0	12.5	12.5	2
July	12.0	7 0	10.0	13.0	15.0	17.0	19.0	19.0	18.0	13.0	12.0	13.0	12.0	12.0	1
August	21.7	21.0	20.0	21.3	18 7	17.0	16 7	17.3	18.0	16.3	14.3	14.3	14.3	12.7	3
September	17.2	16.9	18.2	17.5	14.7	14.5	15.3	16.5	15.5	16.2	15.2	14.2	13.2	10.7	6
October	15.9	15.4	15.3	15.8	15.8	16.4	17.3	17.6	16.9	16.0	15.1	13.9	14.3	14 1	10
November	16.0	17.5	17.0	16.5	17.3	17.5	18.0	16.8	15.8	15.3	14.8	16.0	17.5	15.8	4
December	13.7	16.0	18.3	20.3	20.7	21.0	19.7	19.7	16.0	14.0	13.3	15.7	15.7	12.0	3

Tab. IV. Average width of sclerites at different distances from the margin of the scale, the distances expressed as the corresponding length increments of the fish.

Cod 40 cm and more.

D. **Topdalsfjord 1926 & 1927.**

	Distance of sclerite from margin of scale, in cm of fish length														Number of fish examined
	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1926															
October	16.5	16.3	15.9	15.9	15.8	15.3	15.5	15.0	14 6	13.4	13.1	13.3	13.1	13.7	35
November	16.0	16.2	15.9	16.2	15.7	15.2	14.1	15.2	15.4	15.5	14.5	14.0	13.4	12.7	19
December	15.3	16.6	16.4	16.0	15.2	13.6	13.1	12.2	12.8	13.2	13.6	12.7	12.7	12.4	12
1927															
January	14.0	14.0	14.0	14.3	13.5	13.8	13.7	13.7	13.7	14.8	14.9	14.3	13.3	12.2	12
February	16 0	16.2	15.3	15.2	15.1	14.8	14.9	15.2	15.7	17.0	16.5	15.2	13.8	12.5	10
March	15.0	14.4	14.6	14.5	14 7	15.5	16.1	16.5	16.1	15.1	14.2	13.5	12.9	11.8	13
April	15.1	15.7	16.2	16.2	16.3	16.2	16.1	16 3	14.6	14.4	14.2	13.0	12.6	11.7	18
May	15.9	16.2	16.0	15.3	15.1	15.3	15.6	15.2	14.9	15.2	15.0	14.1	13.0	12.1	18
June	14.9	14.8	15.1	15.9	15.9	15.4	14.4	13.7	13.8	13.8	14.1	14.1	13.4	12.0	10
July	16 6	16.9	16.3	15.9	16.3	16.4	16.4	15.6	15.5	15.8	16.2	16.4	16.1	13.6	20
August	16.9	16.1	16 3	15.7	15.9	14.9	14.3	15.7	16.3	17.5	18.8	17.4	15.9	13.8	18
September	20.0	18.7	17.3	16.7	15.3	16.7	19.4	20.3	19.4	19.0	19.0	20.0	17.3	14.3	3
October	18.0	17.5	16.0	14.5	16.5	18.5	17.0	17.0	16.0	11.5	11.0	15.0	16.0	17.0	2
November	15.1	14.9	14.1	14.5	15.7	16.2	16.3	16.7	16.1	15.8	14.7	14.5	15.1	12.7	9
December	13.6	13.4	13.7	14.3	16.5	18.2	19.4	20.0	18.2	16.6	14.3	13.6	13.2	11.1	7

Tab. V. **Cod Søndeledfjo**

Group A—C for each quart

Length cm:		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Group A.	4					2													
B.	1		2	6	8	7	10	11	3	5	1								
	2	1	1	1	10	17	20	25	28	25	18	9	7	4	4	3			
	3		1	6	5	13	26	36	19	27	19	15	16	8	6	2	1		
	4		1	1	6	13	17	30	30	31	17	28	21	19	16	12	9	13	7
C.	1			2		4	18	29	27	30	23	47	54	54	53	46	29	27	31
	2					1	6	16	19	24	40	42	76	63	50	57	44	53	47
	3			1	1	1		2	3	10	4	17	19	19	23	5	21	19	24
	4									2	2	1	3	1	6	4	7	9	6
D.	1 & 2								1		1	2	1	3	5	8	10	9	19
	3 & 4												1	1	2	1	1	5	2
E.	1 & 2																	1	2
	3 & 4																		
F.	1 & 2																		
	3 & 4																		
G.	1 & 2																		
	3 & 4																		
H.	1 & 2																		
	3 & 4																		
I.	1 & 2																		
	3 & 4																		
	Total	1	5	17	30	58	97	149	130	154	125	161	198	172	165	138	122	136	138

22—1929 (inclusive).

e remainder for each half year.

	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
	1																							
		1																						
3	2	1	1									1												
4	10	9	3	3			2		1															
4	18	20	20	8	1	4	5	1	0	1	1													
0	26	17	15	7	9	8	3		2	2														
3	7	8	8	10	2	6	3	3	4						1		1		1					
8	21	33	25	19	24	34	24	12	20	11	8	6	5	4	2	2	2							
7	7	3	8	5	8	2	10	10	8	2	1	7	6	7	1	1		2			2			
4	5	3	13	8	10	4	13	6	10	14	10	19	6	8	8	6	7	9	3	3	1	2	1	1
1			1	1		3		1	7	6	2	1	4	3	2	1	1	2	2		1	2		1
	1		1		2	2	5	4	3	1	3	3	3	10	1	5		2	4	3	1	1	2	1
				1			1		2		1			2	1	1				1				
					1						1		4	1	1		2	1		2		1	2	
			1																					
															1		1							
4	98	95	96	62	57	63	66	37	57	37	27	37	28	35	18	16	14	16	10	9	5	6	5	3

Tab. V (cont.). **Cod Søndeledfj**

Group A—C for each quar

		Length cm:	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Group A.		4																		
		1																		
B.		2																		
		3																		
		4																		
		1																		
C.		2																		
		3																		
		4																		
D.	1 & 2																			
	3 & 4		1																	
E.	1 & 2							1												
	3 & 4																			
F.	1 & 2		2	3	1	2			1				1							
	3 & 4													1						
G.	1 & 2						1													1
	3 & 4					1				1			1	1						
H.	1 & 2			1				1		1					1		1			
	3 & 4																			
I.	1 & 2								1											
	3 & 4															1				
	Total		3	4	1	3	1	2	2	2			2	2	1	1	1			1

922—1929 (inclusive).

e remainder for each half year.

2	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	.....	104	Total	Average
																				2	23.0 cm
																				54	24.0 „
																				173	26.0 „
																				202	26.6 „
																				283	28.8 „
																				529	31.2 „
																				673	32.9 „
																				316	35.5 „
																				107	38.5 „
																				348	41.5 „
																				115	44.0 „
																				179	47.9 „
																				44	50.2 „
																				69	53.0 „
																				11	52.1 „
																				18	56.2 „
																				5	64.8 „
																				7	66 0 „
																				0	
						1													1	3	87.0 „
								1												2	83.0 „
						1		1											1	3140	

Tab. VI.

Cod Flødevig

Group A—C for each quart

	Length cm:	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Group A	4		1	1		1																					
„ B	1	2	2	6	4	9	4	3	3	1	2	0	1	1													
	2	1	3	4	9	11	8	6	7	5	5	1	5	3	0	1	1	0	0	1							
	3	1	5	6	5	9	10	8	5	3	10	2	2	0	2	2	1	0	0	1							
	4		2	4	8	6	6	13	8	15	14	14	18	15	15	9	4	4	7	3	1	3	0	1			
„ C	1		1	1	2	4	4	10	10	17	18	13	17	12	21	14	15	16	4	10	3	8	1	4			
	2							1	4	6	4	6	10	9	11	10	10	9	10	6	7	7	5	5	5	1	5
	3											1	2	1	2		2	3	1	4	8	2	5	1	2	6	3
	4																		3	2	3	1	3	3	2	4	5
„ D	1 & 2																	1		1	1	1		1	2		4
	3 & 4																				1				1		2
„ E	1 & 2																									1	
	3 & 4																										
„ F	1 & 2																										
	3 & 4																										
„ G	3 & 4																										
	Total:	4	14	22	28	40	32	41	37	47	53	37	55	41	51	36	33	33	25	28	24	22	14	15	12	12	19

23—1929 (inclusive).

e remainder for each half-year.

47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	..	77	Total	Average
																										3	21.3 cm
																										38	23.5 „
																										71	25 2 „
																										72	25.2 „
																										170	29 0 „
2																										207	31.1 „
	2	2	2	1																						145	35.5 „
			2																							51	39.4 „
6		1	1	3	1						1															45	43.8 „
4	5	4	6	3	2	2	3	4	3	2		2			1											58	49.2 „
1		1				1		2	2		1	3			2	1	1	1								20	54.5 „
		1			1		1	1								1			1				1			8	56.5 „
									1	1				1	1			1								5	60.2 „
																							1			1	70.0 „
																		1							1	2	71.0 „
13	7	9	11	7	4	3	4	7	6	3	2	5		1	4	2	1	3	1				2		1	896	

Tab. VII. **Cod Topdalsfjo**

Group A—C for each quart

	Length cm:	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Group A.	4					2			1	1									
„ B.	1			1	3	3	1			1		1	1						
	2		2	3	5	5	10	9	15	9	9	2	2	2		2		1	
	3		5	3	15	9	12	15	15	17	28	21	35	15	10	14	7	7	2
	4			3	3	2	3	3	4	3	7	7	26	17	31	18	17	29	7
„ C.	1		1	1	2	2	1	1	2	1	4	6	2	3	6	6	5	13	3
	2					2	2	1	4	3	4	5	5	9	5	8	14	20	13
	3						1	2	2	4	2	3	2	3	4	5	2	13	12
	4							1		1			1	2	3	3	2	6	5
„ D.	1 & 2									1			1		1		3	1	2
	3 & 4				1									2				4	
„ E.	1 & 2																		
	3 & 4																		
„ F.	1 & 2																		
	3 & 4																		
„ G.	1 & 2																		
	3 & 4																		
„ H.	1 & 2																		
	3 & 4																		
	Total:		8	11	29	25	30	32	43	41	54	45	75	53	60	56	50	94	44

24—1929 (inclusive).

remainder for each half year.

39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
1																							
				2																			
3	5	1	1	2	1	2	1	1	1	1													
3	1	1	3	1	2			1															
13	11	5	4	5	2	5	1	3	2	1	1		1	1		1							
12	22	6	9	15	11	12	6	3	10	7	3	1					1						
8	19	10	10	9	20	18	15	14	12	15	13	3	6	2	2	1							
7	10	3	12	7	8	10	11	10	8	6	8	3	6	2	2	2	2	3			2		
2	1	6	5	5	6	8	11	8	14	11	16	9	9	11	10	14	7	10	3	2	5	1	6
		1	1	2	2	3			3	3	7		5	4	3	3	2	1	5	8	5	5	3
					1	1	1				1	1	3	3	3	5	1		3	6	6	3	4
						1		2	1					1						2			1
															1				1				
														1									1
																					1		
									1														
49	69	33	45	48	53	60	46	42	52	44	49	17	30	25	21	26	13	14	12	18	19	9	15

Tab. VII (continued).

	Length cm:	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Group A.	4																		
„ B.	1																		
	2																		
	3																		
	4																		
„ C.	1																		
	2																		
	3																		
	4																		
„ D.	1 & 2	1																	
	3 & 4	1	1	2		1			1										
„ E.	1 & 2	2	3	1	2	1		2	1										
	3 & 4	3	1	4			3		5		3	2							
„ F.	1 & 2		1	1			1		1	2		1	2						
	3 & 4								1								1		
„ G.	1 & 2							1	2					1				1	
	3 & 4			1							1	1					1		
„ H.	1 & 2				2			1											1
	3 & 4								1										
	Total:	7	6	9	4	2	4	4	12	2	4	4	2	1			2	1	1

83	84	85	86	87	88	89	90	91	92	93	94	....	....	100	....	....	140	Total	Average
																		4	24.8 cm
																		11	24.2 „
																		77	25.9 „
																		236	28.4 „
																		224	33.0 „
																		80	33.2 „
																		176	36.3 „
																		191	39.7 „
																		214	43.5 „
																		138	45.1 „
																		195	50.3 „
																		78	55.7 „
																		63	60.2 „
																		18	62.8 „
		1		1														6	72.0 „
																		7	68.3 „
											1			1			1	7	88.9 „
																		5	68.2 „
		1					1		1									6	77.8 „
		2		1			1		1		1			1			1	1736	

Tab. VIII. **Length of spawning cod from the Hatchery (for ea**

Length cm:	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Group 3											1	1		1	2	1		2	2	1
„ 4			1			1									2	1	2	2	3	1
„ 5															2	2				1
„ 6																			1	
„ 7																	1			
„ 8																				
„ 9																				
„ 10—12																				

Continued.

Length cm:	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Group 3																				
„ 4	14	9	16	13	3	5	1	4												
„ 5	42	30	28	33	19	20	13	16	10	14	3	1	3	2		2	1	2		1
„ 6	16	14	18	25	21	17	19	12	12	8	8	6	11	1	1	3	3	2	1	1
„ 7	6	4	9	9	5	5	5	5	3	9	9	5	3	2	3	1	2	2	2	1
„ 8	2	2	3	1	3	5	2	3	1	3	3	1	1	2	3	3	1	1	1	
„ 9	3						1	2			2		2	1			1	1		1
„ 10– 12			2		2	1		1		1										

e-group) for the seasons 1920, 1921, 1925—1930.

6	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
	2	2		6	1	4	2	5	4	2	4	1	2	3	1	1		
3	5	6	9	8	4	15	13	9	10	14	11	27	32	35	39	28	24	27
2	4	8	3	3	13	10	9	9	23	16	15	31	34	38	40	45	36	35
1	1	1		2	2	5	4	2	3	6	4	12	4	11	15	7	18	15
			1			1	1	3	3	2	5	1	3	5	5	5	7	3
1				1			1	1					2		2	3	1	4
											1	2	1	2	4		1	2
															1		2	

6	97	98	99	100	101	102	103	104	105	....	....	....	109	110	Total	Average
															51	61.2 cm
															403	69.0 „
															620	72.5 „
	1														316	76.6 „
							2		1						141	78.4 „
		1			1										60	80.2 „
	1			1					1				1		31	80.9 „
		1		1	1										14	83.6 „
															1636	

Tab. IX. **Cod Flødevigen 1914—15—16—20—21—2**

Group A—C for each quart

	Length cm:	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Group A.	1																										
	2																										
	3		1	1	5	10	3	1																			
	4														2	3	7	1	1								
„ B.	1					1	4		2	4	8	7	8	20	17	25	44	39	45	28	22	16	8	3	5	1	
	2						1	1	2	7	5	8	3	7	5	9	5	12	10	11	8	11	10	7	3	1	1
	3									1		3	2	2	1	2	6	13	7	7	8	8	8	8	3	4	2
	4															3	1	3	2	3	7	8	12	8	17	12	13
„ C.	1																5	5	5	7	13	10	17	17	15	17	18
	2																1			1	2	2	4	8	8	15	16
	3																		1	1	3	4	9	4	5	8	5
	4																							1	4	2	1
„ D.	1 & 2																										
	3 & 4																										
„ E.	1 & 2																										
	3 & 4																										
„ F.	1 & 2																										
	3 & 4																										
„ G.	1 & 2																										
	3 & 4																										
„ H.	1 & 2																										
	3 & 4																										
	Total:		1	1	5	11	8	2	4	12	13	18	13	29	25	42	69	73	71	58	63	59	68	56	60	60	50

he age computed by the scales.

ie remainder for each half year.

2	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
		1	1																					
3	4	8	3	2		1		1	1															
0	12	7	4	5	5	8	4		1															
3	7	9	3	6		1	2	3		1		1												
3	5	7	6	4	6	4	3	1	2	3	3	1	1			2								
4	4	3	7	8	7	3	2	5	4	1	1	1	1	1		3								
1	7	3	5	5	8	9	5	7	6	13	5	7	2	4	4	1	6	5	2		2	1	2	
					1	1		2	5	3	6	2	4	1	1	4	1	4	2	2	2	1	1	
										3	1	3			2	1	2	5	2	1	3	3	3	2
																			1			1	1	
																				1	1	1		1
4	39	38	29	30	27	27	16	19	19	24	16	15	8	6	7	11	9	14	7	4	8	7	7	3

Tab. IX (continued).

Length cm:		57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
Group A.	1																		
	2																		
	3																		
	4																		
„ B.	1																		
	2																		
	3																		
	4																		
„ C.	1																		
	2																		
	3																		
	4																		
„ D.	1 & 2				1														
	3 & 4	1	1	1						1									
„ E.	1 & 2	2		1	1	1				1	1		1		2	1			
	3 & 4	2	1	1	1	3	3	3	1										
„ F.	1 & 2	1	1		2	1	2	1		1	1	1	1		3				
	3 & 4				1					2	1	1	1		1				
„ G.	1 & 2						1	1							2				
	3 & 4																		
„ H.	1 & 2														1				
	3 & 4																		1
Total.		6	3	3	6	5	6	5	1	5	3	2	3		9	1			1

77	78	79	80	..	90	..	93	..	95	..	97	..	101	..	106	.	120	Total	Average
																		21	8.8 cm
																		14	19.7 „
																		307	20.6 „
																		127	20.8 „
																		91	23.7 „
																		128	28.5 „
																		211	29.2 „
																		102	31.0 „
																		101	32.7 „
																		69	36.0 „
																		113	41.6 „
																		47	46.9 „
																		42	53.3 „
																		18	59 6 „
		1							1									21	64.2 „
			1												1			9	71.9 „
					1				1									7	75.0 „
																		1	70.0 „
1							1				1		1				1	6	93.7 „
1		1	1		1		1		2		1		1		1		1	1435	

Tab. X. **Length of the Cod.**

Hjort & Dahl: SW of Norway, August.
Oslofjord 19/9, 1899—20/1, 1900.
Dahl: Søndeledfjord 25/11, 1905.
Dannevig: Søndeledfjord 1/10—31/12, 1922—1929.

	Hjort & Dahl 1900		Dannevig	Dahl	Dannevig	Dahl
Age	1 1/2	1 3/4	1 3/4	2 3/4	2 3/4	3 3/4
Cm						
16	1					
17	2					
18	2	1				
19	5	3				
20	4	1	1			
21	3	8	1			
22	2	11	6	1		
23	11	11	13			
24	11	30	17			
25	11	28	30			
26	5	28	30	6		
27	9	20	31	14	2	
28	4	46	17	11	2	1
29	1	28	28	15	1	3
30	2	32	21	8	3	4
31		21	19	8	1	5
32		46	16	1	6	6
33		32	12		4	9
34		45	9		7	5
35		30	13	1	9	5
36		42	7		6	3
37		18	4	1	9	1
38		32	3		3	1
39		7	2		7	
40		13	1		8	2
41		2	1		8	
42					10	
43					2	
44					6	
45					3	
46					3	
47					4	
48						
49						1
50			1*)			
51						
52						
53					1	
54						
55					1	
56						
57					1	
Number:	73	535	283	66	107	46
Average:	23.8	31.0	28.8	28.6	38.5	33.2

*) The length apparently not correct.

Tab. XI.

Showing the results of Dahl's marking experiments 1904—1905.

Liberation:		Recapture:									
Date, locality	No. marked	No. (%)	Duration of liberty:			Distance n. m. from place of liberation:					
			min.	average	max.	0–1	1–2	2–3	3–4	4–5	≦5
Nordfjord:											
$^{20}/_{4}$—$^{31}/_{5}$ 1904 ...	45	6 (13.3)	141	223	327	3		1	2		
Outside the skjærgård:											
$^{27}/_{8}$—$^{2}/_{9}$ 1904 ...	76	7 (9.2)	13	81	176	6					1
Nordfjord midwater oft Narvika:											
$^{1}/_{4}$ 1905.....	100	24 (24)	11	98	349	14	3	4	1	1	1
Outside the skjærgård:											
$^{3}/_{4}$—$^{8}/_{4}$ 1905.....	36	7 (19.5)	9	57	200	5					2
Barmsund (Søndeledfjord):											
$^{12}/_{4}$ 1905.....	112	15 (13.4)	7	65	210	7	4	4			
Håvik, Nordfjord:											
$^{17}/_{4}$ 1905.....	231	34 (14.7)	2	27	180	14	7	9	3	1	
Outside the skjærgård, cod caught in the fjord:											
$^{27}/_{4}$ 1905.....	104	2 (1.9)	8	13	18	2					
The skjærgård outside Risør;											
$^{5}/_{7}$ 1905.....	5										
The harbour of Risør: [1]											
$^{14}/_{4}$—$^{25}/_{4}$ 1905 ...	5	2 40	17	29	41	2					
Outside the skjærgård[1]	3										
	717	97 (13.5)				53	14	18	6	2	4

[1]) Fish previously marked & recaptured.

Tab. XII. Showing the width of sclerites at different length of the fish. Cod reared in the pond.

Liberated as larvae $^{30}/_{4}$, recaptured $^{29}/_{11}$ 1930.

The figures are average values from 5 scales from each individual taken from below the 2nd dorsal. Sloping figures indicate minimum values, heavy maximum values. The last figures given indicate the size of the last sclerite — although the length for fish stated at the top of the column is not fully reached. The values in columns 2 & 3 are partly affected by the central plate of the scale — and therefore too large.

No.	Length of fish in cm																
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
10	22.0	10.0	*6.4*	**7.4**	7.0												
9		*7.2*	8.2	**11.0**	7.2	6.6											
39	22.6	8 0	*6.8*	**8 8**	7.0	6.0											
11	25.6	14.6	7.8	*5.2*	6.6	6.4											
40	8.8	*6.2*	8.6	**9.2**	7.4	6.6											
2	11.2	*6.0*	6.2	**7.8**	7.4	6.6											
38		*6 6*	**8 4**	8.2	8.2	5.8											
6	11.2	*6.4*	7.2	**10 2**	8.2	7.6											
3	10.0	6.4	*6.2*	**8 0**	**8.0**	**8.0**	7.4										
8	10.0	*6 8*	7.8	10.0	10.6	**10 6**	10.2										
5	10.8	*7.2*	10.6	**11.6**	11.5	10.6	8.8										
7	5.8	*6.0*	8.0	**10.4**	9.8	10.0	9.2										
24		*6.8*	6.8	9.8	**12.6**	10.0	7.0	7.4									
18	21.8	*7.0*	7.2	10.2	**11.2**	8.6	8.2	8.2									
25		*4.6*	6.6	9.8	8.2	**9.6**	9 4	7.8									
26		7.4	*6.2*	10.8	10.6	**11.0**	9.8	7.0									
15		10.6	*5.8*	7.4	**12.4**	9.2	8.2	7.6									
12		8.0	*6.4*	9 2	**11.4**	10.2	9.6	10.0									
17	12.6	*6.8*	7.4	**11.2**	10.4	9.8	**11.2**	9.2									
13		6.6	*6.2*	9 6	**10.0**	9.4	9.8	8.2									
14		8.0	*6.0*	10.4	**11.8**	11.4	10.0	9.6	8.6								
19		8.8	*6.8*	8.8	12.2	**12.6**	10.6	9.0	8.6								
21		*7.2*	7.4	10.6	10.0	11.8	**12 0**	9.2	10.0								
16		9.4	*8.2*	9.8	12.8	12.2	**13.2**	13.0	9.6								
23		9.8	*7.4*	9.2	11.2	11.4	11.0	**11.8**	8.6	8.0							
31		7.4	*6.2*	8.4	11.6	11.4	**12.4**	11.0	8.2	7.2							
20		10.8	6.8	6.8	*6.2*	8.2	11.2	**12.0**	9.8	7.6							
22		8.6	*7.6*	9.2	**12 6**	11.0	10.4	11.2	8.4	6.4							
41		14.2	8.4	*7.2*	8.2	11.8	12.4	12.6	11.8	**12.8**	11.6						
30		8.4	*6.8*	8.4	10.6	11.4	10.0	11.2	**13.2**	12.8	12.2						
28		*6.2*	7.4	9.2	10.4	13.0	12.8	12.6	**14.6**	13.4	13.2	13.0					
35		6.4	*6 0*	9.8	12.2	13.2	11.4	12.6	**14.4**	13.6	11.0	11.0					
27		8.4	8.4	*5.6*	7.4	8.8	11.0	10.0	10.0	**12.4**	10.6	10.0					
29		12.4	7.6	*6.2*	7.6	9.2	11.0	11.0	11.6	**12 4**	**12.4**	11.0					
32		11 6	10.0	*7.0*	8.6	10.6	14.2	14.2	12.8	**14.4**	13.2	13.4					
36		10.0	*6.2*	7.8	11.0	11 8	12.2	11.6	13.4	**14.4**	14.0	13.6					
37		11.4	8.2	*6.8*	9.0	10.4	12.0	12.2	14.2	**16.0**	13.8	11.2	11.0				
33		9.6	7.2	*7.0*	7.6	9.6	12.4	12.0	13.2	13.0	**13.8**	13.6	13.8				
34		9.4	7 8	*6.8*	8.0	10.4	11.6	13.8	14.4	14.8	17.0	17.4	**17.6**	17.4			
1		13.4	8.8	8.6	*5 8*	8.0	9.0	14.2	15.0	15.0	15 8	**16.8**	15.6	13.6			
42		12 6	8.4	7.8	*6.6*	8.6	11.0	12.6	14.4	15.6	16.0	16.0	18.0	19.8	**22.2**	21.6	20.0

Table XIII & XIV.

Tab. XIII cod from aquarium.

Tab. XIV cod kept in confinement in the sea.

Giving the computed width of sclerites for each cm length of the cod. The measurements are performed by an enlargement of 165, the result reckoned to half mm but in order to avoid decimals the figures are multiplied by 2. The resulting units are thus equal to 0.0031 mm.

The last figure for each observation gives the size of the last sclerite, although the length stated at the top is not reached. The width of the sclerite on the margin of the scale of a cod 25.3 cm of length will thus be found in column 26.

Tab. XIII.

Date	Exact length cm	No. of scales measured	Length 4	5	6	7	8	9
14/3 1927	20.0	3	13.0	11.7	10.7	11.7	9.7	12.
5/5 1927	20.7	3	14.7	9.7	10.7	9.7	12.0	11.
9/7 1927	25.5	3	12.7	10.7	11.0	10.7	12.0	10.
8/10 1927	31.0	3	12.7	10.7	11.7	9.7	11.0	12.
8/12 1927	33.5	3	12.7	11.3	11.3	9.7	12.7	11.
8/2 1928	34.3	3	12.7	12.0	10.7	10.3	12.3	12.
16/4 1928	37.0	3	15.3	13.0	11.3	10.7	10 0	12.
22/5 1928	37.7	5	13.0	11.0	11.2	10.0	10.0	11.
		Average:	13.3	11.3	11.1	10.3	11.2	11.

Tab. XIII (cont.).

Date	Exact length cm	No. of scales measured	Length 22	23	24	25	26	27
14/3 1927	20.0	3						
5/5 1927	20.7	3						
9/7 1927	25.5	3	18.0	18.7	18.0	16.0	14.7	
8/10 1927	31.0	3	17.3	18.0	19.3	16.7	17.0	14.
8/12 1927	33.5	3	19.0	20.0	18.0	16.0	15.3	17.
8/2 1928	34.3	3	19.0	19.3	19.3	18.7	18.7	18.
16/4 1928	37.0	3	10.3	13.7	17.3	17.3	17.7	17.
22/5 1928	37.7	5	14.2	17.2	17.8	18.0	17.4	16.
		Average:	16.3	17.8	18.3	17.2	16.8	16.

). 1.

h in cm

10	11	12	13	14	15	16	17	18	19	20	21
1.7	11.3	10.3	14.3	16.0	20.7	17.7	16.7	18.3	17.0	16.0	
1.3	12.0	15.7	17.7	19.3	18.0	17.0	17.7	18.7	19.0	14.7	13 0
0.0	11.7	13.3	16.3	18.3	16.0	15.3	16.3	17.3	11.7	12.0	15.7
1.0	12.0	11.0	15.3	16.7	16.0	14.7	15.7	15.3	13.0	11.7	14.0
1.3	11.0	14.7	16.7	17.3	16.0	16.3	17.3	16.0	13.0	13.7	17.0
1.3	11.7	13.0	16.7	17.0	16.3	15.7	16.3	16.0	12.7	13.3	15.7
2.0	10.7.	11.3	13.0	15.3	16.7	17.0	15.0	15.0	16 7	16.0	13.3
1.2	10.4	12.0	13.4	14.8	16.8	16.4	15.8	15.4	16.2	14.0	11.6
1.2	11.3	12.7	15.4	16.8	17.1	16.3	16.4	16.5	14.9	14.0	14.4

h in cm

28	29	30	31	32	33	34	35	36	37	38	
4.7	13.3	13.7	13.7								
6.7	18.0	17.3	18.0	18.7	19.0	19.0					
6.3	15.3	15.0	18.3	18.0	18.3	16.0	14.7				
5.0	14.3	14.0	13.3	13.3	14.7	17.3	18.3	18.0	15.3		
4.6	15.4	13.4	13·8	14.8	15.2	16.6	15 2	11.4	13.0	13.4	
5 4	15.3	14.7	15.4	16.2	16.8	17.2	16.0	14.7	14.2	13.4	

Tab. XIII.

Co

Date	Exact length cm	No. of scales measured	Length 4	5	6	7	8	9	10
5/5 1927	25.8	3	12.0	9.0	7.3	7.0	14.7	17.0	18.
9/7 1927	28.8	3	9.7	9.0	6.3	7.3	15.3	19.7	22.
8/10 1927	33.0	3	10.7	9.3	5.7	9.0	15.7	20.0	19.
8/12 1927	35.0	3	9.0	7.3	5.3	10.0	15.7	18.7	20.
8/2 1928	36.7	3	11 3	10.0	6 0	6 0	13.0	18.7	20.
16/4 1928	37.5	3	11.7	10.7	9.0	6.0	10.0	16.7	20.
1/6 1928	37.7	4	9.5	9.7	6.0	6 7	13.7	17.7	19.
3/7 1928	38.5	5	9.6	10.0	7.2	6.4	13.4	18.0	19.
1/8 1928	38.5	4	11.2	9.5	6.5	8.0	13.5	17.2	18.
4/9 1928	38.6	5	8.8	10.0	7.4	6.4	13.8	18.2	20.
3/10 1928 ...	40.0	5	11.0	8.8	7.4	8.2	13.0	17.0	20.
1/11 1928	41.0	4	11.3	8.8	7.3	8.8	13.3	17.3	19.
4/12 1928	41.0	2	11.0	9.0	6.0	11.0	17.0	22.0	20.
2/1 1929	41.5	5	9.2	8.2	6.4	11.0	15.0	18.8	19.
Average:			10.4	9.3	6.7	8.0	14.1	18.3	19.

Tab. XIII (cont.).

Date	Exact length cm	No. of scales measured	Length 24	25	26	27	28	29	30
5/5 1927	25.8	3	14.7	13.7	12.0				
9/7 1927	28.8	3	12.0	14.3	15.0	15.3	14.7	14.0	
8/10 1927	33.0	3	12.3	12.3	13.3	15.7	16.3	12.7	13.
8/12 1927	35.0	3	11.3	13.7	17.0	15.3	13.7	15.0	16.
8/2 1928	36.7	3	12.7	11.7	12.7	15.7	17.3	16.0	13.
16/4 1928	37.5	3	18.0	14.7	13.3	12.7	12.0	15.0	15.
1/6 1928	37.7	4	15.5	12.2	11.0	12.5	12.5	15.0	14.
3/7 1928	38 5	5	14.8	11.6	11.0	12.4	15.6	13.4	12.
1/8 1928	38.5	4	11.5	12.2	14.2	14.2	15.2	13.5	13.
4/9 1928	38.6	5	12.4	11.6	12.2	13.8	14.2	14.0	12.
3/10 1928	40.0	5	13.6	12.0	12.2	11.2	13.4	15.0	14.
1/11 1928	41.0	4	15.0	15.3	13.8	13.5	12.5	13.8	13.
4/12 1928	41.0	2	15.0	14.0	14.5	13.0	15.5	13.0	14.
2/1 1929	41 5	5	12.4	13.2	13.0	13.8	15.4	15.6	13.
Average:			13.6	13.0	13.2	13.8	14.5	14.3	13.

. 3.

n in cm

1	12	13	14	15	16	17	18	19	20	21	22	23
8.3	16.0	14.0	13.3	12 0	11.3	11.7	13.3	14.7	16.3	18.3	19.0	17.0
1.3	17.0	17.0	15.3	13.3	11.3	12.3	12.0	14.7	16.7	19.0	19.7	15.3
5.7	16.7	16.0	12.7	12.3	12 3	11.0	11.7	12.3	18.0	19.0	18.0	13.7
8.3	15.0	13.3	11.3	11.0	11.7	10.0	13.7	14.3	16.3	15.3	12.3	11.3
9.0	17.7	15.3	14.3	13 3	12.0	11.7	11.3	12.7	15.0	14.7	17.0	15.0
1.3	19.3	18.0	16.0	15.0	12.7	12.3	11.3	12.0	13.7	15.7	18.0	18.7
9.5	18.8	16.5	15.5	13.2	12.5	11.2	12.5	11.5	14.0	16.8	18.0	16.2
9.6	18.2	16.6	14.6	13.2	10.8	11.4	12.0	12.6	15.4	16.8	16.8	15.8
7.8	15.6	13.8	13.0	12.0	11.0	9.8	11.8	12.2	13.8	14.5	14.5	12.8
0.6	19.4	15.0	14.6	13.2	11.6	10.2	11.2	11.0	14.4	16.8	17.2	15.6
0.2	17.8	16 2	15.6	13.8	11.2	11.0	11.4	11.0	13.2	13.6	17.4	17.2
9.5	17.8	17.3	15.0	12.5	11.3	11.0	11.3	13.5	14 8	16.0	17.0	15.8
0.5	16.5	15.0	16.0	14.0	12.5	12.0	12.5	14.5	18.0	19.0	19.5	18.5
7.8	15.4	13.6	11.8	11.2	10.4	11.2	12.2	14.8	16.6	16.2	15.2	14.4
9.2	17.2	15.5	14.2	12.9	11.6	11.2	12.0	12.1	14.4	16.5	17.1	15.5

n in cm

31	32	33	34	35	36	37	38	39	40	41	42	43
3.3	13.3	13.3										
4.0	17.0	17.7	17.7	15.0	14.0							
3 7	14.0	16.0	17.0	17.0	17.0	15.7						
4.0	14.7	14.7	13.3	14.7	16.0	15.3	14.0					
5.0	12 8	13.8	15.8	16.0	15.5	13.5	13.8					
0.8	14.2	14.8	15.6	14.4	14.4	14.8	13.6	12.6				
3.0	13.8	13.8	12.2	13.2	13.5	14.2	13.8	14.5				
2.4	13.4	14.0	14.6	14.0	13.8	14.0	12.8	13.0				
3.0	13.2	13.4	15.0	14.2	13.6	13.0	14.0	15.6	13.2			
3.0	14.0	14.2	15.2	13.8	14.5	14.2	13.2	13.0	15.0	15.0		
3.5	14.5	15.0	15.0	15.0	15.0	12.5	14.0	13.5	12.5	13.0		
4.4	14.2	14.0	14.6	14.2	11.4	13.2	13.8	13.2	13.4	13.4	13.8	
3.4	14.1	14.5	15.1	14.7	14.4	14.0	13.7	13.6	13.5	13.8	13.8	

Tab. XIII (cont.).

Date	Exact length cm	No. of scales measured	Length of f				
			4	5	6	7	8
3/7 1928	25.3	5	13.8	12.2	11.4	10.8	9.4
1/8 1928	25.7	4	12.8	11.8	12.0	10.8	11.8
4/9 1928	26.9	5	14.8	13.0	11.4	10.4	10.2
3/10 1928	27.5	5	16.4	12.6	11.4	10.6	10.0
1/11 1928	28 8	5	24.0	16.2	12.2	11.8	10.0
4/12 1928	30.0	3	14.7	14.0	12.0	12.3	11.0
2/1 1929	30.2	5	14.6	10.4	10.2	8.4	11.0
Average:			15.9	12.9	11.5	10.7	10.5

Tab. XIII (cont.).

Date	Exact length cm	No. of scales measured	Length				
			18	19	20	21	22
3/7 1928	25.3	5	11.8	13.2	16.4	18.6	17.6
1/8 1928	25.7	4	13.8	15.8	18.2	19.0	18.3
4/9 1928	26.9	5	12.4	14.2	17.0	17.0	17.0
3/10 1928	27.5	5	13.8	14.4	16.0	16.2	16.2
1/11 1928	28.8	5	11.8	13.8	15.0	15.8	15.8
4/12 1928	30.0	3	13.0	16.0	17.0	18.0	15.7
2/1 1929	30.2	5	15.0	15.8	15.4	14.0	13.8
Average:			13.1	14.8	16.4	17.0	16.4

o 4.

cm								
9	10	11	12	13	14	15	16	17
11.6	13.4	13.4	12.4	14.8	14.4	11.6	11.0	11.6
13.8	13 0	12.3	14.5	15 3	12.8	12.0	13.0	12.8
12.2	13.4	13.2	12 8	14.6	14.4	12.8	12.0	13.6
11.4	11.2	11.6	11.4	14.4	13.4	11.0	10.2	11.4
11.4	12.4	13.0	11.6	13.2	13.6	12.0	11.0	11.2
12.3	12.7	13 0	11.7	14.7	15.3	12.7	12.7	11.0
11.6	12.2	13.4	13.8	11.6	10.6	11.6	10.4	12.8
12.0	12.6	12.8	12.6	14.1	13.5	12.0	11.5	12.0

h in cm								
23	24	25	26	27	28	29	30	31
15.0	16.4	15.0	13.6					
16.3	14.5	14.5	12.5					
15.0	14.6	15.0	13.4	14.0				
15.0	12.0	12.8	11.2	11.0	13.4			
15.2	13.0	11.8	13.4	13.6	11.8	14.2		
16.0	14.3	13.3	11.7	10.7	9.3	10.3	11.3	
13.4	13.8	10.8	9.8	13.4	13.2	13.0	14.8	15.2
15.3	14.1	13.3	12.2	12.5	11.9	12.5	13.1	15.2

Tab. XIII. C

Date	Exact length cm	No. of scales measured	Length 4	5	6	7	8	9	10
11/3 1929	30.5	3	17.0	12.7	9.3	7.3	8.3	11.7	13
12/4 1929	31.4	3	17.3	13.3	11.3	7.0	7.7	9.0	14
4/5 1929	34.0	3	17.7	17.0	11.7	9.0	7.7	9.0	12
3/6 1929	34.5	3	14.3	11.3	7.7	7.3	7.3	10.7	12
3/7 1929	35.0	3	19.3	11.7	9.7	8.0	6.7	8.7	11
6/8 1929	36.5	3	25.7	13.3	8.3	9 0	7.7	8.3	12
5/9 1929	37.8	3	18.3	13.0	11.0	8.3	9.0	10.7	13
5/11 1929	41.5	3	16.3	15.0	9.3	8.0	7.7	8.3	11
5/12 1929	41.6	3	26.3	12.0	9.0	7.3	8.3	10.7	12
6/1 1930	41.7	3	27.3	13.0	9.0	9.0	7.3	8.3	10
8/2 1930	42.6	3	31.3	12.0	9.3	7.3	8.0	12.7	12
5/3 1930	42.8	3	15.0	12.0	8.0	9.7	11.3	9.0	11
10/4 1930	43.0	3	13.0	10.3	8.0	7.0	8.3	11.7	13
		Average:	19.9	12.8	9.4	8.0	8.1	9.9	12

Tab. XIII (cont.).

Date	Exact length cm	No. of scales measured	Length 24	25	26	27	28	29	30
11/3 1929	30.5	3	13.7	12.3	14.0	15.7	15.7	12.7	12
12/4 1929	31.4	3	13.7	11.3	15.0	16.7	15.7	16.0	16
4/5 1929	34.0	3	11.0	11.7	10.3	11.0	12.7	16.7	15
3/6 1929	34.5	3	11.3	12.7	12.7	15.0	12.7	14.0	11
3/7 1929	35.0	3	10.7	11.3	14.7	15.0	14.0	12.7	10
6/8 1929	36.5	3	12.7	12.7	13.3	14.3	15.0	13.7	12
5/9 1929	37.8	3	13.3	13.7	13.7	14.3	14.3	13.0	11
5/11 1929	41.5	3	9.7	9.7	11.0	13.3	13.7	13.7	11
5/12 1929	41.6	3	12.7	12.3	14.0	14.0	14.0	13.7	11
6/1 1930	41.7	3	12.7	11.7	13.3	15.0	15.3	14.7	12
8/2 1930	42.6	3	13.3	14.7	15.0	13.7	14.0	13.3	12
5/3 1930	42.8	3	12.3	15.0	15.7	15.3	12.3	14.0	11
10/4 1930	43.0	3	14.0	10.7	13.7	13.0	14.0	12.7	13
		Average:	12.4	12.3	13.5	14.3	14.1	13.9	12

ıo. 5.

sh in cm

11	12	13	14	15	16	17	18	19	20	21	22	23
12.0	10.7	15.3	15.0	17.0	15.3	15.7	16.0	15.0	14.3	11.0	12.7	11.0
10.7	10.0	12.7	10.7	12.0	15.7	16.0	18.7	20.0	15 3	13.0	10.3	12.0
11.3	10.0	11.3	10.7	10.3	11.3	14.3	16.3	17.7	18.0	17.0	15.7	12.7
8.0	9.0	11.3	7.7	13.3	16.7	18.0	16.7	16.7	15.7	13.0	11.7	11.7
12.0	12.0	11.3	9.3	10.7	14.7	13.7	15.7	17.3	14.0	14.0	8.7	11.0
8.7	11.0	12.0	9.3	10.7	13.7	15.7	17.7	16.7	16.7	14.0	10.7	10.7
12.7	8.7	13.0	11.7	14.0	16.7	15.7	16.7	17.3	16.7	15.0	14.0	14.7
10.3	9.7	10.0	10.7	8.3	13.3	14.7	15.7	17.0	15.3	15.0	11.7	10.0
10.0	10.0	10.7	10.3	9 0	14.3	16.0	17.3	17.0	15.7	12.7	11.3	10.7
11.7	10.3	11.3	12.0	9.3	13.3	16.0	17.0	17.0	16.0	14.0	12.0	11.7
9.3	11.3	12.0	11.3	15.0	15.0	16.7	18.7	17.0	15.7	12.3	12.7	12.0
12.0	11.3	10.7	12.3	16.3	18.0	17.3	16.0	14.7	12.7	11.3	12.7	12.3
9.7	12.0	11.7	10 7	12.3	16.0	16.7	16.0	17.7	17.0	16.0	14.0	14.3
10.6	10.4	11.8	10.9	12.2	14.9	15.9	16.8	17.0	15.6	13.7	12.2	11.9

sh in cm

31	32	33	34	35	36	37	38	39	40	41	42	43
12.0												
14.3	8.3											
16.7	14.7	12.7	9.0									
12.7	11.7	13.3	11.7	11.7								
11.0	14.3	14.7	14.3	10.7								
11.7	14.3	14.3	14.3	12.3	12.0	12.0						
13.7	14.3	15.0	11.7	12.3	14.0	15.7	13.3					
9.7	12.0	14.7	14.0	14.7	14.7	12.0	8.7	11.0	12.3	13.0	12.0	
11.3	12.0	13.3	16.0	11.7	11.7	8.3	8.7	9.3	11.7	11.0	11.3	
9.0	12.7	14.0	14.3	13.3	7.3	8.0	10.7	11.3	12.3	13.7	13.0	
8.7	13.3	14 7	13.3	12.3	11.3	13.3	12.3	13.7	13.7	13.7	14.3	8.7
11.0	14.3	13.0	12.7	10.3	14.3	13.3	14.0	15.7	14.3	13 7	14.0	14.0
13.3	11.7	10.3	17.3	17.0	14.0	13.0	13.3	13.3	13.7	14.0	12.3	14.3
11.9	12.8	13.6	13.5	12.6	12.4	12.0	11.5	12.4	13.0	13.1	12.8	12.3

Tab. XIII. Co

Date	Exact length cm	No. of scales measured	Length 4	5	6	7	8	9
11/3 1929	26.5	3	12.0	9.3	5.7	11.3	15.3	15.0
12/4 1929	27.2	3	12.0	8.0	9.0	11.7	15.7	17.0
4/5 1929	27.5	3	12.0	9.3	7.3	12.0	13.3	15.3
3/6 1929	29.0	3	14.0	10.7	7.0	8.3	12.3	17.0
3/7 1929	30.2	3	14.3	12.3	8.0	8.7	11.3	13.3
6/8 1929	31.0	3	16.3	12.0	8.7	7.0	12.7	14.0
5/9 1929	31.0	3	12.0	8.7	6.7	9.0	11.7	17.0
5/11 1929	32.8	3	13.3	9.3	6.3	11.7	12.7	15.0
5/12 1929	34.2	3	12.7	9.7	12.0	14.7	16.7	16.0
6/1 1930	34.5	3	13.0	10.3	6.3	7.7	12.0	16.7
8/2 1930	34.6	3	15.7	10.0	7.7	12.3	14.0	17.0
5/3 1930	35.0	3	13.3	9.0	6.3	8.7	14.0	16.3
10/4 1930	35.0	3	14.7	9.7	7.0	13.0	16.0	16.0
1/5 1930	36.0	3	10.7	8.3	7.7	9.3	11.3	18.0
		Average:	13.3	9.7	7.6	10.4	13.5	15.9

Tab. XIII (cont.).

Date	Exact length cm	No. of scales measured	Length 21	22	23	24	25	26
11/3 1929	26.5	3	11.0	13.0	12.7	11.3	11.7	9.3
12/4 1929	27.2	3	12.7	13.3	13.0	14.3	12.0	13.3
4/5 1929	27.5	3	14.3	12.7	15.0	12.3	13.3	15.7
3/6 1929	29.0	3	13.7	14.3	14.7	13.0	12.0	13.3
3/7 1929	30.2	3	11.7	12.7	14.0	13.7	10.3	11.7
6/8 1929	31.0	3	13.0	13.7	12.7	12.3	12.3	11.7
5/9 1929	31.0	3	12.3	13.3	12.0	11.3	9.3	10.7
5/11 1929	32.8	3	12.0	12.7	12.7	11.0	12.3	11.3
5/12 1929	34.2	3	16.7	14.7	13.7	14.0	15.7	12.3
6/1 1930	34.5	3	11.7	12.0	11.7	12.3	11.0	11.3
8/2 1930	34.6	3	13.0	13.3	12.3	11.3	12.0	12.7
5/3 1930	35.0	3	13.3	14.3	15.3	15.0	14.7	13.3
10/4 1930	35.0	3	12.3	13.3	14.0	11.7	10.3	12.3
1/5 1930	36.0	3	15.0	14.3	15.3	15.0	15.7	12.3
		Average:	13.0	13.4	13.5	12.7	12.3	12.2

o. 6.

sh in cm

10	11	12	13	14	15	16	17	18	19	20
15.0	13.7	14.7	14.3	13.0	11.7	8.7	9.7	11.3	10.7	12.0
15.7	17.3	14.7	16.7	14.3	13.0	10.7	10.3	10.7	12.0	12.3
15.7	15.3	16 0	14.0	12.0	11.7	9.3	11.7	11.3	13.0	13.3
18.3	17.0	17.3	17.0	16.7	12.0	11.7	8.0	10.7	13.3	12.0
15.7	16.3	14.7	15.7	14.3	12.7	10 0	10.3	11.7	12.0	9.3
17.3	18.0	18.7	19.0	15.7	13.0	12.7	8.0	10.7	13.3	10.3
15.7	16.3	14.7	13.7	13.0	9.7	9.7	9.7	9.7	10.0	11.0
16.7	16.0	16.0	15.7	13.7	11.3	9.0	7.7	12.7	11.0	12.0
17.7	16.7	16.3	15.3	13.0	12.7	12.3	12.3	12.0	14.7	15.7
17.7	18.0	18.0	17.0	16.3	12.7	10.7	9.0	8.3	12.0	11.7
17.7	17.0	17.3	17.7	17.7	12.0	12.3	11.0	12.0	12.7	12.3
19.0	17.0	16.7	15.0	14.3	13.3	10.3	8.7	8.7	12.0	12.0
17.7	15.3	15.7	15.7	15.7	13.3	9.0	11.7	10.3	12.7	10.7
19.0	19.3	18.7	18.7	17.0	13,3	11.0	10.3	11.7	13.0	13.7
17.1	16.7	16.4	16.1	14.8	12.3	10.5	9.9	10.9	12.3	12.0

sh in cm

27	28	29	30	31	32	33	34	35	36	
8.3										
14.3	14.3									
15.0	15.0									
12.0	11.7	12.0								
11.3	10.7	10.7	10.3	10.3						
11.7	10.0	12.7	10.0	11.7						
10.3	10.7	8.0	8.7	12.0						
12.7	12.0	7.3	10.3	12.7	12.3	12.3				
13.3	12.3	10.7	9.0	9.3	13.7	12.7	13 3	13.3		
11.3	10.7	7.0	11.0	11.0	11.0	12.0	12.3	12.3		
11.7	7.7	9.3	12.3	12.0	12.7	12.3	14.0	14.0		
10.3	11.3	11.0	10.7	10.3	11.3	12.3	12.3	12.7		
7.3	7.7	10.0	10.7	10.0	9.7	11.0	13.7	14.0		
14.7	10.7	12.7	11.7	12.7	13.0	11.7	11.0	11.7	14.3	
11.7	11.1	10.1	10.5	11.2	11.9	11.9	12.8	13.0	14.3	

Tab. XIV. Co

Date	Exact length cm	No. scales measured	Length 4	5	6	7	8	9	10	11
3/7 1928	26.0	3	13.7	13.0	12.3	10.7	11.7	9.3	9.0	13.0
1/8 1928	26.5	3	17.0	14.3	12.7	10.0	10.3	10.3	8.0	11.3
4/9 1928	26.7	3	19.3	12 7	14.3	10.7	10.0	10.7	8.0	9.3
3/10 1928	27.0	3	15.0	12.0	11.3	10.3	10.7	8.3	9.7	12.7
1/11 1928	27.0	1	14.0	12.0	12.0	10.0	10.0	10.0	10.0	12.0
4/12 1928	27.7	3	14.3	13.7	11.0	11.3	10.7	9.3	10.3	12.3
2/1 1929	28.4	3	13.3	14.7	14.0	10.0	10.7	7.0	11.0	12.0
2/3 1929	28.6	3	17.0	13.3	12.3	10.7	11.3	9.0	8.7	12.7
12/4 1929	28.6	3	15.0	13.0	12.7	10.7	10.3	10.0	9.3	9.0
4/5 1929	29.0	3	15 3	15.7	13.3	12.3	11.3	10.7	9.7	10.0
3/6 1929	29.6	3	16.0	12.0	11.7	11.3	11.0	8.7	11.3	11.0
3/7 1929	30.2	3	15.0	13.7	11.7	10.7	10.7	8.3	10.0	11.7
6/8 1929	32.2	1	16.0	12.0	10.0	10.0	9.0	7.0	9.0	11.0
5/9 1929	33.7	2	15.5	12.0	10.0	9.0	8.0	9.0	8.5	10.5
5/11 1929	37.2	1	14.0	12.0	11.0	10.0	11.0	5.0	10.0	10.0
5/12 1929	38.6	3	13.7	12.3	11.3	11.0	8.7	13.7	14.3	14.3
6/1 1930	39.7	3	16.3	12.7	12.3	10.3	10.0	11.7	11.7	12.0
8/2 1930	39.7	3	15.7	12 7	11.7	10.7	8.7	9.3	12.0	13.3
5/3 1930	40.9	1	16.0	12.0	12.0	11.0	8.0	14.0	16.0	16.0
10/4 1930	40.6	1	13.0	12.0	10.0	11.0	11.0	10.0	10.0	12.0
1/5 1930	41.8	3	22.0	12.7	10.7	10.0	10.0	8.7	9.0	11.7
		Average:	15.6	12.9	11.8	10.5	10.1	9.5	10.3	11.8

Tab. XIV (cont.).

Date	Exact length cm	No. of scales measured	Length 24	25	26	27	28	29	30	31
3/7 1928	26.0	3	19.3	14.3	12 3					
1/8 1928	26.5	3	17.3	14.3	14.0	15.0				
4/9 1928	26.7	3	13.7	10.7	10.7	12.0				
3/10 1928	27.0	3	14.7	13.3	12.7	13.3				
1/11 1928	27.0	1	16.0	13.0	10.0	11.0				
4/12 1928	27.7	3	10.0	10.3	11.3	12.3	14.0			
2/1 1929	28.4	3	11.3	8.3	10.3	12.0	12.7	12.3		
2/3 1929	28.6	3	19.0	18.3	16.0	10.3	11.7	10.7		
12/4 1929	28.6	3	16.3	14.3	12.3	8.3	9.0	9.3		
4/5 1929	29.0	3	18.3	17.3	11.7	10.0	9.7	12.0		
3/6 1929	29.6	3	16 3	13.7	12.7	11.7	10.0	9.0	10.0	
3/7 1929	30.2	3	16.7	14.7	13.0	10.3	9.7	11.7	11.3	11.3
6/8 1929	32.2	1	6.0	6.0	8.0	9.0	10.0	9.0	11.0	10.0
5/9 1929	33.7	2	13.0	12.0	6.5	6.5	7.5	11.0	10.5	11.0
5/11 1929	37.2	1	10.0	7.0	8.0	6.0	8.0	11.0	9.0	11.5
5/12 1929	38.6	3	13.3	10.7	7.3	8.7	14.0	14.7	15.3	12.5
6/1 1930	39.7	3	12.3	9.0	9.0	9.0	12.3	13.0	13.0	12.3
8/2 1930	39.7	3	9.3	7.3	8.7	10.7	10.0	12.7	12.7	12.3
5/3 1930	40.9	1	19.0	9.0	13.0	6.0	11.0	11.0	14.0	17.5
10/4 1930	40.6	1	19.0	11.0	15 0	6.0	8.0	8.0	11.0	17.5
1/5 1930	41.8	3	15.0	12.7	9.0	8.0	6.7	8.3	10.3	11.3
		Average:	14.6	11.7	11.0	9 8	10.3	10.9	11.7	12.3

o. 1.

h in cm

12	13	14	15	16	17	18	19	20	21	22	23
4.0	14.3	15.0	13.3	13.7	14.3	14.0	15.0	18.7	20.7	21.7	21.0
2.0	14.0	15.3	13.7	11.7	12.3	12.7	13.3	16.7	19.0	19.0	17.7
1.0	11.7	12.7	12.7	11.3	12.3	12.0	12.0	11.3	15.7	17.7	15.0
3.0	14.0	13.3	13.0	12.7	12.7	13.0	14.7	18.3	19.3	19.0	18.3
2.0	14.0	14.0	11.0	12.0	14.0	12.0	14.0	18.0	18.0	18.0	17.0
3.0	14.0	13.7	13.7	12.7	13.3	13.3	13.7	17.3	18.3	18.7	16.3
2.7	12.3	12.7	12.0	11.7	11.7	12.3	15.0	16.3	17.0	17.3	15.7
4.0	12.0	15.0	13.3	11.7	12.3	11.7	13.7	15.7	16.3	18.7	19.0
1.7	11.7	12.7	12.3	10.3	10.7	11.7	11.0	11.0	15.3	16.7	17.7
2.0	13.0	13.3	13.3	13.0	13.0	13.7	12.3	13.3	16.7	18.7	19.0
2.7	13.7	12.7	11.7	12.0	13.0	12.7	13.0	14.3	16.0	17.0	16.7
2.3	14.0	15.0	13.7	13.0	12.7	15.0	16.3	17.7	18.3	20.3	19.3
2.0	12.0	10.0	11.0	14.0	12.0	13.0	16.0	16.0	16.0	13.0	10.0
2.5	12.0	12.0	13.0	11.0	12.0	11.5	10.5	11.5	13.5	13.5	14.5
2.0	8.0	13.0	13.0	14.0	11.0	11.0	12.0	18.0	15.0	14.0	10.0
7.0	14.0	16.0	16.7	16.3	17.3	18.3	20.3	23.7	23.0	23.0	19.3
3.7	12.0	12.7	13.3	13.0	11.3	14.3	16.0	18.3	18.7	16.7	12.3
4.7	12.0	12.3	12.0	13.0	13.7	13.7	19.3	19.7	19.3	17.3	14.0
8.0	15.0	16.0	16.0	16.0	16.0	17.0	20.0	20.0	25.0	22.0	22.0
2.0	16.0	13.0	10.0	15.0	14.0	15.0	18.0	25.0	25.0	21.0	21.0
0.0	12.3	13.0	11.7	11.3	10.3	11.7	12.0	14.0	17.3	18.0	16.0
3.0	12.9	13.5	12.9	12.4	12.4	13.3	14.6	16.9	18.3	18.1	16.7

sh in cm

32	33	34	35	36	37	38	39	40	41	42	
3.0	13.0										
9.5	8.5	9.0									
0.0	10.0	12.0	12.0	6.0	10.0	10.0					
1.7	11.0	12.0	14.7	15.0	15.0	14.3	14.3				
1.7	10.0	15.0	15.7	15.3	16.0	15.0	14.0	13.3			
2.0	11.7	13.3	14.0	16.0	17.0	15.3	13.0	12.7			
2.0	8.0	14.0	16.0	18.0	16.0	18.0	18.0	18.0	16.0		
5.0	14.0	12.0	11.0	12.0	15.0	13.0	14.0	16.0	16.0		
3.0	14.7	15.3	12.7	10.3	15.0	14.7	15.0	13.0	15.0	15.0	
2.0	11.2	12.8	13.7	13.2	14.9	14.3	14.7	14.6	15.6	15.0	

Table XIV (cont.).

Date	Exact length cm	No. of scales measured	Length 4	5	6	7	8	9	10
3/7 1928	29.6	3	24.3	17.3	15.3	13.0	11.3	12.3	13
1/8 1928	30.0	3	18.3	16.3	15.3	13.0	12.7	11.3	11
4/9 1928	31.0	3	31.7	19.7	15.0	13.0	13.0	13.7	12
3/10 1928	32.0	3	30.7	20.3	17.3	15.7	12.7	12.7	11
1/11 1928	34.5	3	33.0	22.0	13.7	11.3	10.7	10.3	9
4/12 1928	36.0	3	31.7	21.3	18.7	17.0	14.0	13.3	12
2/1 1929	37.0	3	25.7	19.0	16.0	14.0	13.0	12.0	11
2/3 1929	39.0	3	19.7	17.7	14.0	13.7	14.3	14.3	12
12/4 1929	39.0	3	32.0	17.3	17.3	13.7	13.0	13.0	13
4/5 1929	41.0	3	24.0	16.0	16.3	12.3	14.3	13.3	12
3/6 1929	41.0	3	33.0	17.3	17.3	13.3	13.3	11.0	11
3/7 1929	42.0	3	19.3	16.0	16.7	13.7	13.7	13.0	13
Average:			27.0	17.5	16.0	13.6	13.0	12.5	12

Table XIV (cont.).

Date	Exact length cm	No. of scales measured	Length 24	25	26	27	28	29	30
3/7 1928	29.6	3	13.7	17.3	18.3	16.3	16.0	15.3	15
1/8 1928	30.0	3	17.7	18.0	17.0	18.0	17.3	16.3	14
4/9 1928	31.0	3	17.0	16.3	16.0	16.3	15.7	14.7	14
3/10 1928	32.0	3	16.7	16.0	14.7	14.3	12 3	10.0	10
1/11 1928	34.5	3	12.7	14.7	14.0	13.7	13.7	10.3	10
4/12 1928	36.0	3	14.7	17.0	16.0	16.3	15.7	13.7	11
2/1 1929	37.0	3	14.3	16.0	15.7	15.0	14.7	13.3	13
2/3 1929	39.0	3	17.3	18.0	20.0	21.3	19.7	18.7	18
12/4 1929	39.0	3	11.7	13.0	17.3	17.3	17.0	16.7	14
4/5 1929	41.0	3	14.3	14.7	19.3	18.7	21.3	21.3	18
3/6 1929	41.0	3	15.3	15.3	17.3	17.3	15.3	14.7	12
3/7 1929	42.0	3	14.7	14.3	16.7	18.3	18.3	16.0	16
Average:			15.0	15.9	16.9	16.9	16.4	15.1	14

o. 2.

sh in cm

11	12	13	14	15	16	17	18	19	20	21	22	23
9.3	10.3	10.0	10.0	9.3	12.0	13.0	12.3	10.3	11.0	12.7	13.3	13.3
8.7	10.0	10.0	10.0	11.7	13.0	14.7	13.7	10.3	12.0	12.3	13.3	15.7
10.0	9.3	10.3	11.3	11.7	10.7	15.0	12.7	12.3	13.3	13.7	13.7	14.3
10.7	9.7	11.3	10.3	12.0	14.0	14.7	11.3	11.3	13.3	12.7	13.7	15.3
8.0	8.0	7.3	8.3	10.0	11.7	13.0	10.0	8.7	11.0	11.0	10.0	10.7
11.3	11.0	10.0	10.0	10.7	12.7	13.7	12.7	13.3	13.0	10.7	11.7	12.0
10.0	10.0	10.0	9.3	10.0	12.3	13.0	12.0	11.0	10.7	11.3	11.7	13.0
11.7	12.7	11.3	12.0	10.7	14.3	16.7	18.3	13.7	13.0	14.3	18.0	15.7
10.7	11.0	10.0	10.7	9.3	10.0	11.0	14.7	16.3	13.0	9.7	10.7	13.3
12.0	12.7	10.7	10.3	11.7	14.3	16.7	16.7	15.3	14.0	14.0	12.3	13.3
9.7	11.3	10.0	10.7	11.3	12.3	14.3	14.0	11.0	10.3	9.3	11.3	12.0
11.3	11.0	11.7	10.7	12.0	10.3	12.0	18.3	16.3	14.3	12.7	12.0	13.3
10.3	10.6	10.2	10.3	10.9	12.3	13 9	13.9	12.5	12.4	12.0	12.6	13.5

sh in cm

31	32	33	34	35	36	37	38	39	40	41	42	43
13.3												
10.7	13.0											
11.3	13.0	12.0	12.0	12.0								
11.0	10.7	12.7	11.7	14.0	13.0							
11.7	10.7	11.7	12.3	14.0	14.0	15.0						
16.7	12.3	10.3	11.0	13.3	14.0	13.0	13.7	11.7				
12.0	12.7	10.0	10.3	9.0	12.0	11.3	11.3	10.0				
18.0	12.7	10.3	13.0	14.0	13.7	13.0	12.3	14.0	11.3	11.3		
11.7	12.3	11.3	11.7	11.3	10.7	13.0	12.7	12.7	13.0	12.0		
10.7	9.3	9.0	10.0	10.3	13.3	13.3	13.3	14.0	14.7	14.7	14.7	
12.7	11.9	10 9	11.5	12.2	13.0	13.1	12.6	12.5	13.0	12.7	14.7	

Table XIV (cont.).

Date	Exact length cm	No. of scales measured	Length 4	5	6	7	8	9	10
27/4 1928	28.0	3	22.7	19.3	16.7	15.0	14.7	15.0	15.
1/6 1928	29.8	3	37.7	23.3	14.7	15.7	13.7	13.7	14.
3/7 1928	29.8	3	22.0	17.0	15.0	14.7	15.7	15.0	15.
1/8 1928	31.6	3	38.3	30.3	22.0	16.0	15.0	14.3	15.
4/9 1928	32.2	3	44.0	31.3	20.7	17.0	14.0	14.7	15.
3/10 1928	32.8	3	26.0	27.3	16.7	14.0	13.0	14.0	13.
1/11 1928	34.0	3	39.3	25.7	18.7	14.0	14.0	14.3	14.
4/12 1928	36.8	3	27.0	21.7	18.0	16.3	15.7	14.7	14.
2/1 1929	37.7	3	33 3	21.7	15.7	13.3	13.0	13.0	13.
2/3 1929	38.5	3	17.3	16.7	15.7	14.7	14.0	12.7	14.
12/4 1929	38.8	3	18.3	17.7	15.7	17.0	15.7	14.0	15.
4/5 1929	40.5	3	34.7	19.3	18 7	16.3	15.7	14.0	14.
3/6 1929	41.0	3	20.0	18.0	16.3	14.7	13.7	13.0	12.
3/7 1929	42.6	3	22.3	22.3	16.0	16.7	14.7	14.7	14.
Average:			28.8	22.2	17.2	15.2	13.5	14.0	14.

Table XIV (cont.).

Date	Exact length cm	No. of scales measured	Length 24	25	26	27	28	29	30
27/4 1928	28.0	3	18.3	17.3	16.7	17.3	16.0		
1/6 1928	29.8	3	14.7	13.7	13.3	15.3	16.3	15,7	12.
3/7 1928	29.8	3	17.3	15.7	17.3	19.0	15.7	14.3	14.
1/8 1928	31.6	3	16.0	16.0	14.3	14.7	12.7	14.0	13.
4/9 1928	32.2	3	19.0	16.3	14.0	14.3	15.7	16.0	13.
3/10 1928	32.8	3	14.7	15.3	13.7	13.0	12.3	12.7	12.
1/11 1928	34.0	3	14.7	16.0	14.3	14.0	13.7	13.7	10.
4/12 1928	36.8	3	15.7	15.7	15.3	13.3	13 0	13.0	13.
2/1 1929	37.7	3	15.0	14.7	13.7	11.3	11.0	11.7	10.
2/3 1929	38.5	3	12.3	16.7	17.0	12.7	13.7	11.0	10.
12/4 1929	38.8	3	17.3	16.7	18.0	13.7	13.7	15.0	14.
4/5 1929	40.5	3	14.0	14.3	14.7	14.0	12.0	13.0	12.
3/6 1929	41.0	3	16.0	14.3	13.3	14.0	13.3	13.3	10.
3/7 1929	42.6	3	15.0	15.3	14.3	13.0	12.0	13.3	11.
Average:			15.7	15.6	15.0	14.2	13.6	13.6	12.

o. 4.

h in cm

11	12	13	14	15	16	17	18	19	20	21	22	23
15.0	13.7	12.7	11.0	11.3	11.7	13.0	14.3	15.3	17.7	20.0	19.7	19.0
14.3	12.3	12.7	12.3	12.0	13.3	14.0	15.3	16.3	17.3	17.0	16.7	16.3
14.0	13.0	12.0	12.7	13.0	16.7	18.3	19.3	19.7	19.7	19.7	18.0	19.0
14.7	14.3	14.3	15.0	11.3	11.3	13.0	15.7	16.7	17.7	18.7	19.7	18.7
15.0	15.0	12.7	11.0	11.3	12.3	12.3	16.0	17.3	18.0	18.0	17.7	17.7
13.7	12.7	11.7	10.0	11.0	10 7	13.0	15.0	16.3	16.7	17.0	16 3	15.7
13.7	14.0	12.0	10.7	11.0	11.3	13.0	15.3	16.3	17.0	16.3	16.7	16.7
13.3	13.7	12.0	12.0	11.3	10.7	12.0	13.3	15.0	17.3	16.7	16.3	16.7
13.0	12.0	12.3	10.7	11.3	11.7	11.7	13.0	14.7	15.7	16.0	15.7	15.3
13.7	12.0	11.0	11.7	11.3	9.0	12.0	15.3	17.0	18.0	19 3	16.7	15.3
15.7	13.3	12.3	11.3	11.7	11.7	12.3	14.7	17.3	18.3	17,3	18.0	16.0
14.3	13.3	12.3	11.3	10.7	11.0	10.0	10.7	12.3	14.0	16.0	14.7	14.3
13.3	12.3	11.3	10.7	10.0	10.3	11.0	12.3	15.7	16.3	16.7	16.0	15.0
13.7	13.0	12.7	10 7	10.7	10.0	10.7	12.3	12.7	14.7	15.7	18.0	17.0
14.1	13.2	12.3	11.5	11.3	11.5	12.6	14.5	15.9	17.1	17.5	17.2	16.6

h in cm

31	32	33	34	35	36	37	38	39	40	41	42	43
14.0	13.7											
14.0	13.7	14.0										
14.0	14.0	14.7										
10.7	13.7	13.7	16.3									
11.7	10.7	10.3	12.0	13.3	13.7	12.7						
11.0	8.7	8.7	10.0	12.0	13.0	13.7	14.0					
10.0	9.3	11.3	10.7	12.0	14.0	11.3	10.3	10.3				
11.0	9.3	7.7	9.7	13.0	12.7	12 7	14.3	14.3				
9.7	8.0	8.0	8.3	8.3	10.7	10.7	12.3	11.7	12.7	12.7		
9.7	10.0	7.7	10.3	10.3	10.7	13.7	12.7	14.0	14.3	14.3		
11.3	8.7	8.7	11.3	11.3	12 0	12 7	14.7	15.0	15.0	13.0	13.7	13.7
11.6	10.9	10.5	11.1	11.4	12.4	12.5	13.0	13.0	14 0	13.3	13.7	13.7

Table XIV (cont.).

Date	Exact length cm	No. of scales measured	Length 4	5	6	7	8	9	1
3/7 1928	20.4	3	15.3	14.0	10.7	10.3	8.3	12.3	13
1/8 1928	20.6	3	15.0	10.0	9.7	8 0	11.0	12.7	13
4/9 1928	20.6	3	16.0	12.3	10.0	10.0	10.3	11.3	12
3/10 1928	21.0	3	18.3	12.0	9.7	9.3	10.7	12.0	12
1/11 1928	20.8	3	15 3	11.3	11.7	7.7	9.3	13.3	13
4/12 1928	21.7	3	13.7	13.7	10.0	10.7	11,7	14.0	12
Average:			15.6	12.2	10.3	9.3	10.2	12.6	12

o. 5.

h in cm

11	12	13	14	15	16	17	18	19	20	21	22
13.7	13.0	13.7	15.0	18.3	20.0	20.3	20.7	20.7	18.7	17.3	
13.0	13.0	14.3	17.0	20.3	21.3	19.3	18.7	17.7	15.0	14.3	
12.3	12.7	13.3	14.0	16.3	17.0	18.3	19.3	18.3	17.0	14.7	
13.0	13.0	13.0	15.0	16.7	16.7	16.7	17.0	12.3	11.7	13.7	
12.7	13.0	14.0	17.0	20.7	22 0	20 3	17.0	14.7	16.0	16.0	
12.7	12.7	13.7	14.7	16.0	17.0	18.0	15.7	14.7	10.7	13.7	14.7
12.9	12.9	13.7	15 5	18.1	16.0	18.8	18.1	16.4	14.8	14.9	14.7

Table XIV (cont.).

Date	Exact length cm	No. of scales measured	Length 4	5	6	7	8	9	1
27/4 1928	23.5	1	12.0	12.0	11.0	12.0	11.0	11.0	8
1/6 1928	25.5	3	24.3	14.0	13.3	11.3	11.3	11.0	10
3/7 1928	27.0	3	14.3	15.0	12.7	12.7	13.0	11.7	11
1/8 1928	28 7	3	17.3	13.7	13 0	12.0	11.0	11.7	11
4/9 1928	30.5	3	16.7	14.3	12.7	11.7	10.3	11.7	10
3/10 1928	32.0	3	20.3	15 0	14.0	12.7	10.7	11.3	10
1/11 1928	33.8	3	22.3	16.7	11.7	12.7	11.3	11.3	11
4/12 1928	35.0	3	22.0	14.3	13.3	11.0	11.3	11.0	11
2/1 1929	36.2	3	23.0	16 3	13 3	12.0	12.0	11.3	10
2/3 1929	37.4	3	17.7	15.3	14.0	13.0	12.0	11.3	11
12/4 1929	38.0	3	15.3	14 7	14.3	13.3	12.0	11.7	12
4/5 1929	40.0	3	16.0	15.0	14.0	11.7	12.3	11.7	10
3/6 1929	40.9	3	16.0	12.7	12 0	11.0	11.3	11.0	10
3/7 1929	41.2	3	25.3	15.3	12.3	11.7	11.7	11.0	9
Average:			18.8	14.6	13.0	12.0	11.5	11.3	10

Table XIV (cont.).

Date	Exact length cm	No. of scales measured	Length 24	25	26	27	28	29	3
27/4 1928	23.5	1	10.0						
1/6 1928	25.5	3	13.7	13.0	13.3				
3/7 1928	27.0	3	19.7	17.0	15.7	15.3			
1/7 1928	28.7	3	13.3	15.3	15 7	13.3	13.7	13.3	
4/9 1928	30.5	3	14.0	13.0	15.3	14.3	14.0	15.0	15
3/10 1928	32.0	3	15.3	15.3	14.3	13.7	16.3	14.7	15
1/11 1928	33.8	3	14.3	15.0	14.7	13.3	14.3	14.3	14
4/12 1928	35.0	3	15.0	15.3	15.0	13.3	13.7	12.3	14
2/1 1929	36.2	3	14.3	14.7	15.0	10.3	11.7	14.0	15
2/3 1929	37.4	3	13.0	14.0	14.0	15.7	13.3	11.3	14
12/4 1929	38.0	3	16.7	14.0	14.0	14.0	12.0	14.7	14
4/6 1929	40.0	3	12.7	13.0	13.3	13.7	14.7	14.0	12
3/6 1929	40.9	3	14.3	15.0	16.3	14.7	13.7	13.3	10
3/7 1929	41.2	3	13.0	15.0	14.3	14.3	13.7	12.0	9
Average:			14.2	14.6	14.7	13.8	13.7	13.5	13

ıo. 6.

ish in cm

11	12	13	14	15	16	17	18	19	20	21	22	23
12.0	14.0	14.0	13.0	14.0	15.0	18.0	22.0	22.0	19.0	18.0	15.0	11.0
9.3	9.3	10.7	14.3	14.7	12 7	13.0	15.0	14.7	14.0	14.0	14.0	16.0
13.7	17.7	16.0	15.0	18.7	21.0	22.3	20.3	21.3	21.7	20.0	17.3	19.0
9.7	10.3	12.7	14.0	13.0	13.3	15.3	16.0	14.3	13.7	15.7	14.7	13.3
10.3	12.0	15.7	15.0	13.3	13.7	15.0	16.3	15.0	14.3	15.7	15.0	13.7
10.7	10.3	14.7	15.3	12.3	13.0	15.3	15.7	13.3	13.7	15.0	12.0	13.7
10.3	11.0	14.0	15.3	13.3	13.7	17.0	16.0	14.0	15.0	16.0	14.0	14.3
11.0	12.3	14.0	15.0	13.7	16.0	17.3	17 0	15.7	14.3	17.3	17.7	14.7
11.3	11.0	13.7	14.3	14.3	13.3	15.7	16.3	17.0	14.3	14.3	15.0	14.7
11.7	11.7	10.7	14.0	13.7	14.7	13.7	14.7	17.0	16.7	15.7	14.3	15.7
10.7	10.0	8.3	13.0	15 3	15.3	14.0	17.0	18.3	17.7	15.3	15.7	16.7
9.3	9.3	9.3	12.0	14.7	15.0	13.0	16.7	18.0	16.7	14.3	14.3	16.3
10.3	13.0	10.7	15.0	16.7	18.3	18.0	19.3	19.3	15.7	17.3	20.0	19.0
8.3	11.3	13.3	14.7	13.3	13.0	15.7	15.7	15.8	13.7	15 0	13.0	11.7
10.6	11.7	12.7	14.2	14.3	14.8	15.9	17.0	16.8	15.8	15.9	15.1	14.9

ish in cm

31	32	33	34	35	36	37	38	39	40	41	42
14.7											
16.0	17.0										
16.0	17.0	17.0	15.7								
14.3	13.7	14,0	14.7	16.0							
16.0	16.0	15.7	15.7	17.0	17.0	17.0					
12.7	13.3	14.0	15.3	16.3	14.0	15.3	15.3				
12.3	12 3	15.3	14.0	14.3	15.0	13.7	14.7				
12.3	12.0	13.7	16.0	15.7	15.0	14.3	13.3	13.7	14.7		
11.7	11.3	11.0	12.3	15.3	14.3	13.3	17.3	16.7	18.3	16.0	
13.0	12.7	14.0	12.0	12.3	13.3	13.7	15.3	13.3	14.0	14.7	14.7
13.9	13 9	14.3	14.5	15.3	14.8	14.6	15.2	14.6	15.6	15.4	14.7

Table XIV (cont.).

Date	Exact length cm	No. of scale measured	Length 4	5	6	7	8
6/8 1929	21.0	3	12.7	9.7	7.7	8.0	10.7
5/9 1929	22.1	3	13.0	11.3	9.0	8.7	11.0
5/12 1929	28.5	3	13.0	11.0	8.3	8.7	10.0
6/1 1930	30.6	3	11.7	8.0	9.3	9.7	10.0
8/2 1930	31.2	3	13.3	10.7	8.0	6.7	9.0
5/3 1930	31.4	3	14.0	11.0	8.3	7.7	10.3
10/4 1930	32.7	3	14.3	11.3	8.7	7.0	9.0
1/5 1930	33.7	3	13.0	13.7	11.0	8.3	10.7
Average:			13.1	10.8	8.8	8.1	10.1

Table XIV (cont.).

Date	Exact length cm	No. of scale measured	Length 19	20	21	22	23
6/8 1929	21.0	3	17.0	12.0	10.7		
5/9 1929	22.1	3	12.0	14.0	12.0	11.7	11.7
5/12 1929	28.5	3	15.7	13.0	12.7	13.3	16.3
6/1 1930	30.6	3	15.0	9.7	14.3	15.0	19.0
8/2 1930	31.2	3	12.3	10.3	12.3	17.0	19.3
5/3 1930	31.4	3	13.3	9.0	14.0	15.3	15.7
10/4 1930	32.7	3	17.0	12.0	10.3	12.3	16.0
1/5 1930	33.7	3	15.3	13.3	9.3	15.7	16.7
Average:			14.7	11.6	12.0	14.3	16.4

no. 8.

fish in cm

9	10	11	12	13	14	15	16	17	18
9.3	16.3	18.3	20.0	29.0	30.3	28.3	22.7	18.7	18.0
9.7	13.0	17.0	18.7	22.7	23.3	26.3	23.0	18.3	17.0
8.7	13.3	18.0	24.7	26.0	28.0	26.0	24.0	20.7	15.7
12.0	14.0	20.7	25.3	25.3	26.3	26.3	24.0	19.7	19.3
9.0	8.3	16.0	19.3	24.0	24.0	22.3	18.7	18.0	16.7
8.7	11.7	16.3	22.3	26.0	27.0	21.7	21.7	19.7	16.7
8.0	10.7	19.0	21.3	21.3	24.7	25.3	24.3	21.0	17.0
8.7	9.0	12.7	18.3	25.3	28.3	29.7	27.7	22.3	20.3
9.3	12.0	17.3	21.2	24.0	26.4	25.8	23.4	19.8	17.6

fish in cm

24	25	26	27	28	29	30	31	32	33	34
18.0	19.7	22.3	18.7	15.0	13.3					
18.0	16.7	21.7	23.3	22.0	17.7	18.3	19.0			
18.3	19.7	20.3	19.3	18.0	17.7	17.7	16.7	16.7		
16.3	19.7	20.7	19.3	19.0	18.7	17.7	17.3	17.3		
17.3	16.7	16.3	21.0	21.0	15.7	19.3	21.0	16.7	16.7	
19.0	18.7	17.7	19.3	17.7	18.0	21.3	18.7	20.7	16.7	16.7
17.8	18.5	19.9	20.1	18.8	16.9	18.8	18.6	17.8	16.7	16.7

IX. Plates.

Plates I—IV illustrate the formation of the third zone in cod scales and otoliths. The transverse sections of the otoliths photographed are imbedded in Canada balsam. Enlargement x 20. The scales are imbedded in albumen glycerine. Enlargement x 40. The white crosses indicate the zones apparently corresponding to the transparent zones of the otoliths.

In the otoliths reproduced the transparent zone appears at the margin in the early part of August, Pl. II, fig. C. and Pl. III, fig. A. The opaque zone is conspicuous at the beginning of January, Pl. IV, fig. C. In the scale the third dark zone is apparently under formation towards the end of August (Plate III, fig. B.) and is still near the margin on October 27th (Plate III, fig. D.).

In the scales relating to April and May, Plate I, the narrow sclerites outside the cross indicate the winter check. Secondary zones are also visible in some of the other scales (see Plate III, fig. B.) between the first and second ordinary zone.

It should be mentioned that the zones in the otoliths are more conspicuous in the photographs than in nature. The Photographic plate being more sensitive to differences in light than the human eye.

Plate I.

Fig. A & Fig. B:
J. No. 15 — 1924, April 7th. Length 31 cm.
Fig. C & Fig. D:
J. no. 32 — 1924, May 20th. Length 30 cm.

Plate II.

Fig. A & Fig. B:
J. No. 48 — 1924, June 16th. Length 33 cm.
Fig. C & Fig. D:
J. No. 107 — 1924, August 1st. Length 34 cm.

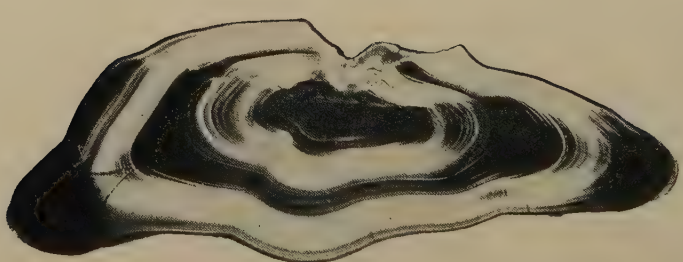
Plate III.

Fig. A & Fig. B:
J. No. 115 — 1924, August 30th Length 34 cm.
Fig. C & Fig. D:
J. no. 131 — 1924, October 27th. Length 36 cm.

Plate IV.

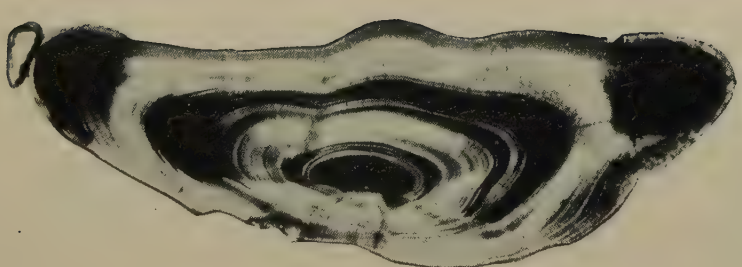
Fig. A & Fig. B:
J. No. 141 — 1924, December 16th. Length 44 cm.
Fig. C. & Fig. D:
J. No. 25 — 1925, January 10th. Length 42 cm.

B



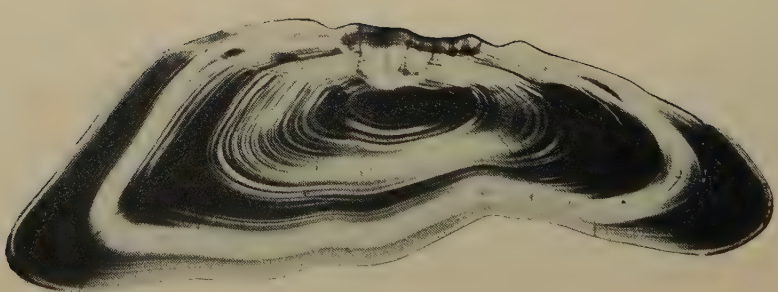
A

D



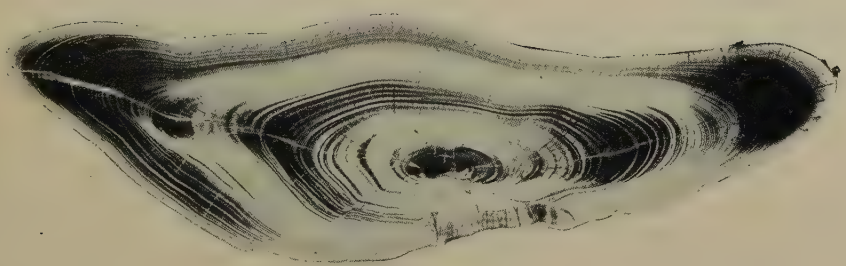
C

B



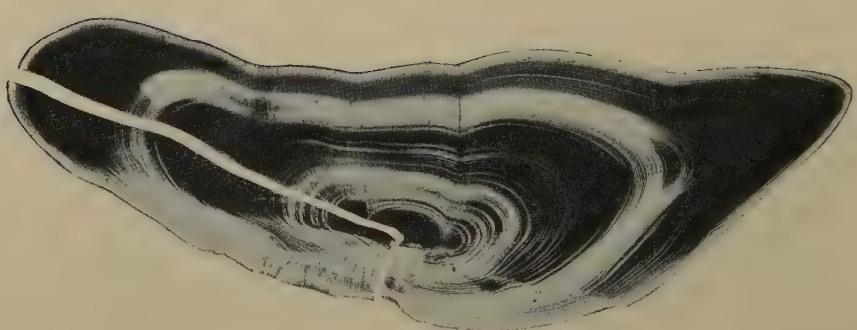
A

D



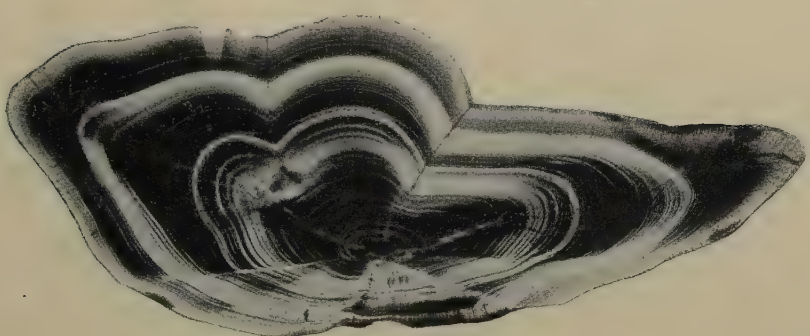
C

B



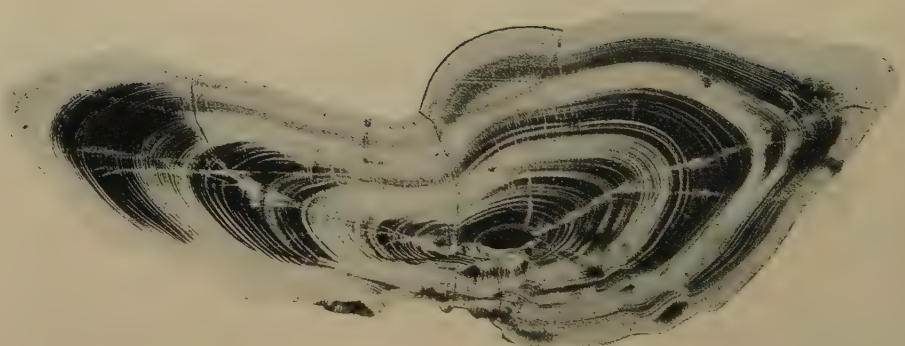
A

D

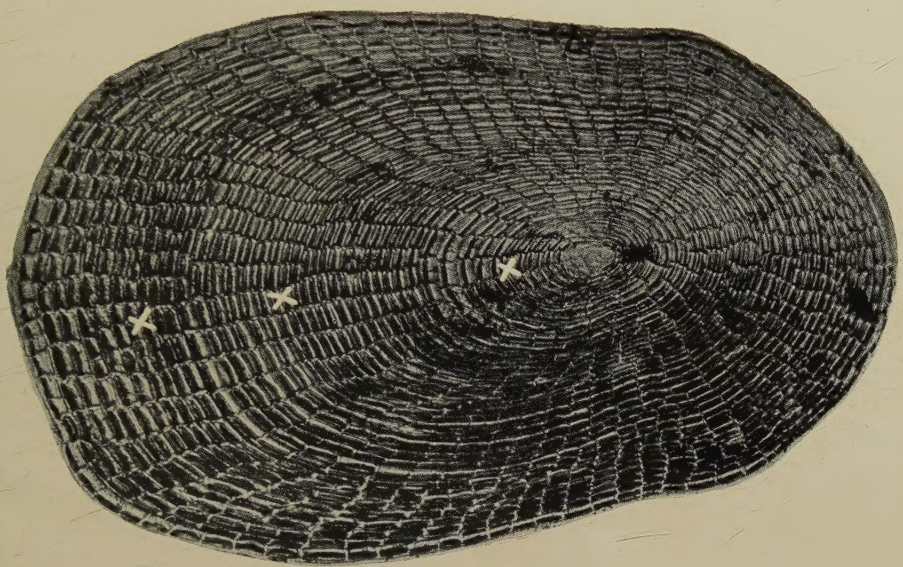


C

B



A



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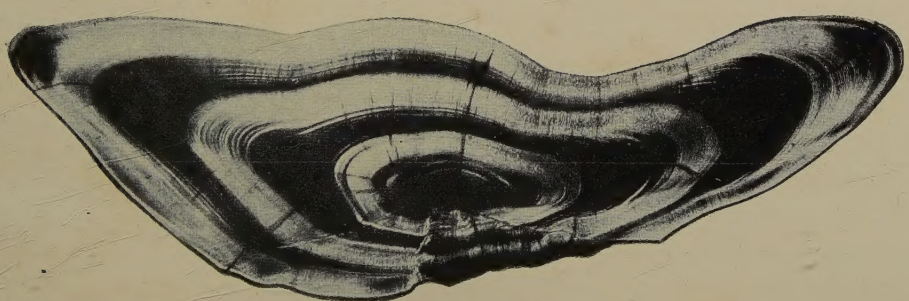

C

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